DOCUMENT RESUME

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IDENTIFIERS	Military Curriculum Project: Relay Circuits: *Telephone Mechanics

ABSTRACT

These individualized, self-paced student texts for a secondary-postsecondary level course for telephone switching equipment repairman are one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in a civilian setting. The five-volume course is designed to provide students with understanding of the theory and normal functions of telephone equipment to permit rapid analysis of telephone troubles. Volume 1, Introduction to Career Field, covers safety switching, review of electronic principles and standard test equipment, supply principles, and fundamentals of management. Volume 2, Telephone Fundamentals, presents an overview of relays and switches, basic telephone principles, and installation fundamentals and familiarization on the operation and maintenance of the AN/FTA 13 manual telephone system. Volume 3, Strowger Step-by-Step Telephone System, discusses application of fundamental information, when step-by-step equipment is used to perform the required switch functions. Volume 4, XY Telephone System, covers this system in the method used in Volume 3. Volume 5, AUTOVON Interface Equipment and Base Wire System, discusses interface circuitry with respect to circuit operation and maintenance and testing and maintenance of the base cable plant to handle AUTOVON and other quality circuits. Each volume contains test materials, review exercises and answers, tests, and supplementary schematic drawings. (YLB)

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EDUCATION & WELFARE
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MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

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Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
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Springfield, IL 62777
217/782-0759

NORTHWEST
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TELEPHONE SWITCHING EQUIPMENT REPAIRMAN (ELECTROMECHANICAL) CDC36251

Correspondence Course 5-6

Developed by:

United States Air Force

Development and Review Dates:

December 1978

Occupational Area:

Communications

Print Pages:

657

Availability:

Vocational Curriculum
Coordination Centers

Suggested Background:

None

Target Audiences:

Grades 10 - Adult

Organization of Materials:

Student text with review exercises and answers, tests, and schematic drawings for referral from each volume

Type of Instruction:

Individualized, self-paced

Type of Materials:		No. of Pages:	Average Completion Time:
Vol. 1:	Introduction to Career Field	69	Flexible
	Schematic 1	1	
	Test 1	12	
Vol. 2:	Telephone Fundamentals and Manual Telephone Systems	156	Flexible
	Schematics 1-7	9	
	Test 2	12	
Vol. 3:	Strowger Step-by-Step Telephone System	91	Flexible
	Schematics 1-10	12	
	Test 3	10	
Vol 4:	XY Telephone System	79	Flexible
	Schematics 1-14	54	
	Test 4	15	
Vol. 5:	AUTOVON Interface Equipment and Base Wire System	103	Flexible
	Schematics 1-10	23	
	Test 5	11	

Chapters 1,3,4, and 5 of volume 1 have been deleted due to military specific materials.

Supplementary Materials Required:

None

rse Description:

This course is designed to provide the student with an understanding of the theory and normal functions of telephone equipment that will permit the rapid analysis of telephone troubles. The course is divided into five volumes as follow:

Volume 1 -- Introduction to Career Field - covers safety switching; review of electronic principles and standard test equipment; supply principles; and fundamentals of management.

Volume 2 -- Telephone Fundamentals and Manual Telephone System - presents materials about relays and switches. It also contains an overview of basic telephone principles as well as installation fundamentals and familiarization on the operation and maintenance of the AN/FTA - 13 manual telephone system.

Volume 3 -- Stowger Step-by-Step Telephone System - discusses application of fundamental information given in previous volumes, when step-by-step equipment is used to perform the required switch functions.

Volume 4 -- XY Telephone System - covers the XY telephone system in almost the identical method the Strowger system was present in volume 3.

Volume 5 -- AUTOVON Interface Equipment and Base Wire System - discusses some of the interface circuitry with respect to circuit operation and maintenance and testing and maintenance of the base cable plant to handle AUTOVON and other quality circuits.

Each volume is accompanied by a supplement of schematic drawings for referral from the readings. Also, each volume contains review exercises and answers, and examinations. Chapters 1,3,4, and 5 of volume 1 have been deleted due to military specific materials.

TELEPHONE EQUIPMENT SWITCHING REPAIRMAN
(ELECTROMECHANICAL) CDC36251

CORRESPONDENCE COURSE 5-6

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NOTE: Chapters 1,3,4, and 5 of volume 1 have been deleted due to military specific materials.

NOTE: Page Number 4 has been omitted.
However, all course material is included.

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CDC 36251

TELEPHONE SWITCHING EQUIPMENT REPAIRMAN (ELECTROMECHANICAL)

(AFSC 36251)

Volume 1

Introduction to Career Field

Extension Course Institute

Air University

PREPARED BY
DEPARTMENT OF COMMUNICATIONS AND MISSILE TRAINING
USAF SCHOOL OF APPLIED AEROSPACE SCIENCE (ATC)
SHEPPARD AIR FORCE BASE, TEXAS

EXTENSION COURSE INSTITUTE, GUNTER AIR FORCE STATION, ALABAMA

THIS PUBLICATION HAS BEEN REVIEWED AND APPROVED BY COMPETENT PERSONNEL
OF THE PREPARING COMMAND IN ACCORDANCE WITH CURRENT DIRECTIVES
ON DOCTRINE, POLICY, ESSENTIALITY, PROPRIETY, AND QUALITY.

Preface

AN EFFICIENT inside plant telephone repairman understands the theory and the normal functions of telephone equipment. This understanding permits him to make rapid analyses of telephone troubles.

CDC 36251 reviews the Wire Communications Systems Maintenance Career Field. Also, it recalls information about electrical fundamentals, transistors, relays, switches, inspection of telephone equipment, tracing of telephone circuits, testing of telephone circuits, and repair of central office equipment. It also covers manual telephone systems and AUTOVON interface maintenance. It introduces SCOPE CAP, a relatively new program that provides you with new tools and techniques for testing and maintaining quality base wire systems.

This "home study" CDC, used along with the skill training provided during OJT, should increase your knowledge and prepare you for undertaking more complex tasks. Meanwhile, you will be helping your organization accomplish its mission. You should recognize during your training that difficult tasks often consist of many simple duties; therefore, when all simple duties are completed correctly, the complex task is accomplished.

This volume, *Introduction to Career Field,* is the first of five volumes. It consists of career field organization; Wire Communication Systems Career Field duties; safety, technical orders, supervision and training, maintenance management, a review of electronic principles and standard test equipment, which includes coverage on the line insulation and equipment routiners; supply principles; and fundamentals of management. Also, you will see a review of electronic fundamentals and a resumé of methods for using technical publications. Some inspections and records are also described in this volume. You will find that this volume builds on your earlier training and that it will aid you when you are studying the four volumes that follow. In addition, it will be useful during your on-the-job proficiency training.

Completion of this volume aids in fulfilling the theory and fundamental knowledge required for AFSC 36251. The total training requirement includes further development through the job proficiency guide (JPG) for the specific equipment and duties of your particular assignment.

Code numbers appearing on figures are for preparing agency identification only.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to SAAS/TTOXU, Sheppard AFB, TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 36 hours (12 points).

Material in this volume is technically accurate, adequate, and current as of December 1978.

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NOTE: Chapters 1,3,4, and 5 of this volume have been deleted due to military specific materials.

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Safety in the Switching Center

ACCIDENTS are usually the result of a failure to think. More accidents are caused by your fellow repairmen (and you?) than by equipment failure. You must think safety and use safe procedures. You must practice them until you no longer have to concentrate to do them. But you must guard against habit taking the place of thought. Performing habitually is effective to a point, but in terms of safety it has been found to have limitations. "Familiarity breeds carelessness."

Since a thorough coverage of safety is available in AFR 127-101, *Accident Prevention Handbook*, we are limiting our coverage of safety to your work area and to a few main hazards. A study of these hazards and your observance of safety rules can result in greater success for you. Furthermore, they could determine whether your life as an airman is short or long lasting.

2-1. Live and Let Live

The practice of safety at a switching center is an important function because of the design of the installation and the equipment. Equipment components are possible accident sources even though they are quite safe under normal conditions. Let us consider the meaning of an "accident source." Then we will discuss "accident causes."

004. Define the terms "accident source" and "accident cause," and tell how they relate to your work area.

Accident Sources. An accident source is not thought to be dangerous; it is an instrument or an activity that has a potential of danger. It becomes harmful when it is handled improperly. For example, soldering irons are sources for accidents. The accident occurs when a man leaves it plugged into a power outlet while he is not in a position to use it, when he places it where it can be accidentally touched, or when he flips it while liquid solder is on the tip. The following accident sources may be in your switching center.

Electrical motors or generators. You learned during your resident course that noise is made up of irregular sound waves that give an unpleasant sensation to the ear. Noise is a byproduct of mechanization. Sound of moderate intensity heard for a long period of time can damage your hearing. Of course, a loud, sudden sound can also damage it. The rotor, cams, belts, etc., turned by a motor are also accident sources.

High-voltage terminals. Any set of exposed contacts that provide a potential of 600 or more volts is a "high-voltage" risk. Lesser voltages can also be dangerous if they cause a current of more than 50 milliamperes within the human body. A wet floor and damp hands can provide a path for a heavy current.

Doors. Equipment doors or gates, if left open when no one is working at the position, can cause severe cuts and bruises.

Chairs. A chair is an accident source when it is used as a substitute for a ladder. In addition, too many accidents have resulted from using a straight-backed chair as a rocking chair.

Metal tools, bracelets, wristwatches, etc. A metallic device can make the equipment inoperative because it can cause short circuits. It also can shock or burn the wearer. If touched to battery terminals, it may cause sparking that could cause gases around the batteries to explode.

Circuit drawers. Removal and replacement of a heavy drawer containing circuits has resulted in strained backs, injured legs, and broken toes. In addition, broken circuits, bent frames, and chipped floors result from drawers being dropped. Prevent these accidents by using gloves and a helper.

Rolling A-type or trolley ladders. Since these ladders operate on wheels, they can move and be moved. For this reason, you must use safety locks (pegs) to prevent their movement. If you put tools on the ladder or carry them carelessly, they can fall on equipment or people on the floor below.

Accident Causes. An accident cause is the unsafe act or unsafe condition that accompanies the accident source. The most frequent cause of accidents is human error. Figure 2-1 indicates that 88 percent of all accidents are caused by unsafe acts of people. The unsafe act may be the result of a man's failure to follow instructions. Or, he may have been unaware of the safety requirements. Likewise, a man failing to recognize unsafe conditions may commit an unsafe act. Figure 2-1 does not show any statistics for unsafe equipment, but the 10-percent rating shown for

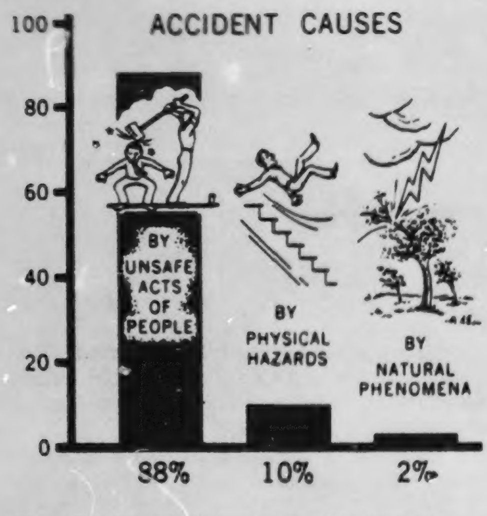


Figure 2-1. The relative importance of accident causes.

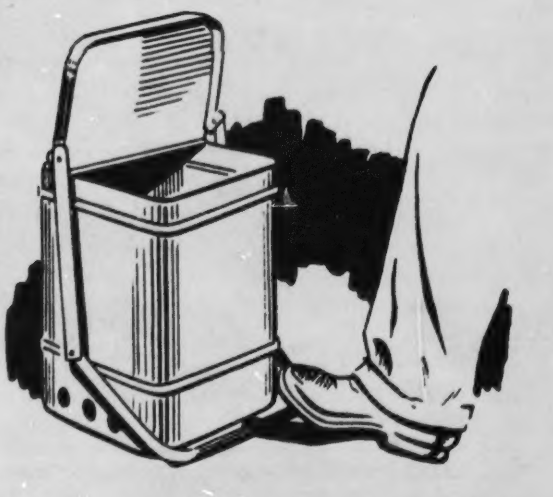


Figure 2-2. Waste can with self-closing foot-operated lid.

physical hazards should include this group. You can see that few accidents are the result of equipment design and operation.

Accident causes, as they apply to this career ladder, can be separated into two types: those that destroy equipment and those that endanger a person's health. Some of the causes fit both categories.

Accident causes that destroy communications equipment. Here are 10 causes of accidents that can destroy equipment.

(1) Smoking in an unauthorized area. The communications equipment room is not an authorized smoking area for several reasons. Smoke is an impurity that causes extra switching equipment maintenance. In addition, there is a strong possibility that battery fumes may be within the area. The hydrogen gas formed during the operation of a battery can explode if it contacts a burning material or a spark.

(2) Failing to place oily rags in self-closing metal containers, one of which is shown in figure 2-2. The container should be carried from the building at the end of the day and the rags removed. This act eliminates the possibility of a fire in the building.

(3) Using gasoline, kerosene, or other flammable fuels for cleaning purposes.

(4) Depositing cigarettes or matches in a wastebasket. Even if the cigarette or match appears to be out, it should never be placed in a wastebasket. Specially identified containers are made for their disposal.

(5) Operating equipment without proper authority.

(6) Failing to follow equipment safety precautions. For instance, many ohmmeters have been damaged because the maintenance man has neglected to remove power from the circuit to be tested.

(7) Operating unsafe equipment. Included in this category is electrical equipment which has not been properly grounded.

(8) Maintaining a messy work area. An example of this condition is a cluttered work space, which can result in the loss of a tiny component. Solder drops left on the floor result in danger to the workmen because they may cause him to stumble and can reduce his insulating protection. Incidentally, dropping melted solder from a high level while performing your work is sheer carelessness in the first place. This solder can cause an undesired connection in the operating equipment.

(9) Wearing loosely hung ID tags or jewelry when working with electrical equipment.

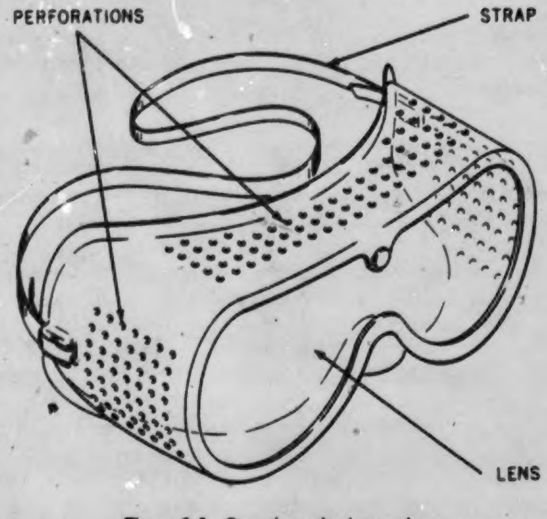


Figure 2-3. One-piece plastic goggles.

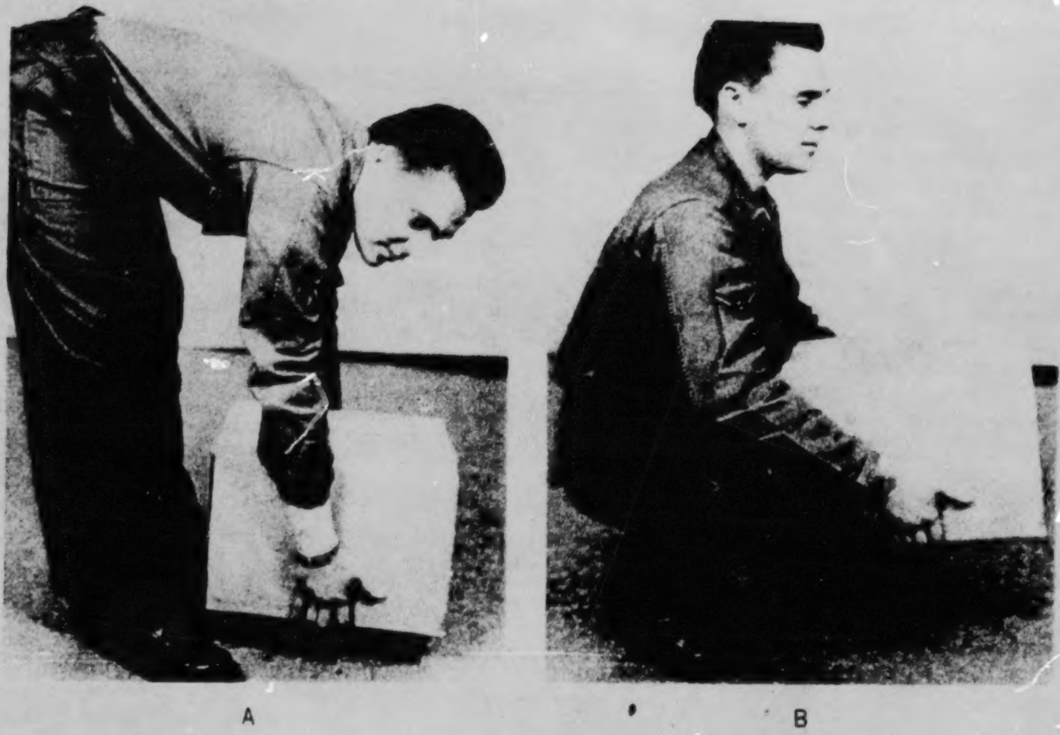
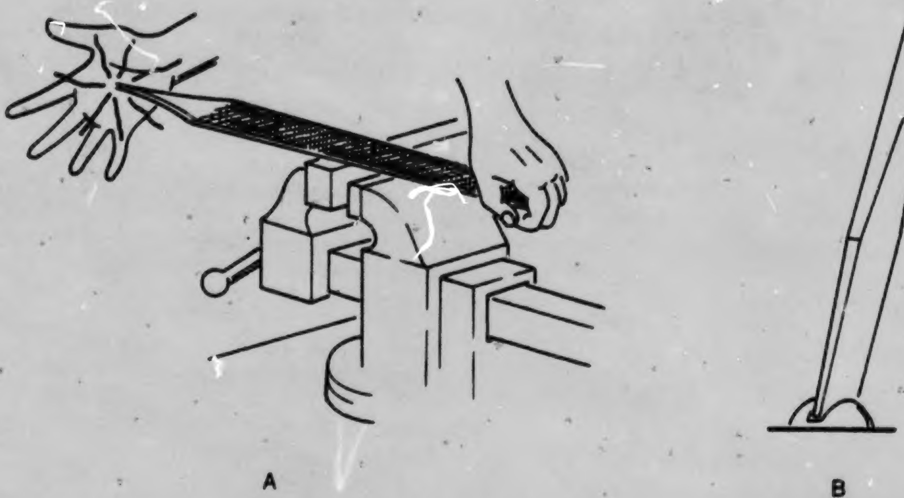


Figure 2-4. Manual lift.



A. FILE   B. SCREWDRIVER

Figure 2-5. Improper use of tools.

(10) Placing containers of soda pop or other liquids on equipment where they can be spilled easily onto the devices of the system.

Accident causes that can result in injury to the maintenance man. Following are eight causes of personal injury accidents.

(1) Failure to use safety clothing and devices. The goggles of figure 2-3 are an example of a protective device that you need when you are soldering. When you are drilling concrete, you also need goggles.

(2) Working at unsafe speeds.

(3) Indulging in horseplay.

(4) Assuming an unsafe body position while you are working. Figure 2-4A shows a man in the improper position for lifting a heavy (50 lbs) object. Figure 2-4B shows the proper position for lifting this carton. The legs are exerting the primary lifting force. NOTE: You may, occasionally, have to assume an unsafe body position because of the construction of the equipment that you are testing or repairing.

(5) Using the wrong tool for the job or using a tool improperly. Figure 2-5A shows a file being used without a handle and the results of this act. Figure 2-5B illustrates the improper positioning of a screwdriver. An inclined or slanting screwdriver can also result in a punctured arm or hand.

(6) Pouring water into acid when making battery electrolyte. If water is added to the sulphuric acid, boiling can scatter the liquid and cause severe acid burns. Spilling electrolyte onto unprotected clothing can also result in acid burns.

(7) Failing to warn individuals of possible dangers or failing to observe warning signs.

(8) Using toxic fluids within a confined area.

Exercises (004):

1. What two factors are a part of every accident?

2. An electric drill, a circuit breaker, a Strowger linefinder, and an XY selector switch are in which of two classifications?

3. Define the two factors that result in accidents.

4. By what means should you dispose of oily rags?

5. What is a possible accident that you could cause when measuring the resistance of a component in an electrical circuit?

005. Given selected situations dealing with live circuits, identify any safety violations present and state the precaution(s) that you should observe.

Live Circuits. Wise maintenance men treat energized electrical circuits with respect and caution. They do not use high-voltage equipment without knowing exactly what is to be done. Avoid equipment marked "DANGER—HIGH VOLTAGE" unless you have been authorized to control it. Even then, handle it with care. For example, wear electrical safety gloves designed for the voltage with which you are going to work. A person who attempts to repair electrical equipment without switching off the power is gambling with death.

Safety devices should never be bypassed or modified without authorization. A blown fuse must be replaced with another fuse of the same current and voltage rating. Have good lighting when you are working with electrical equipment. Use insulating matting on the floor next to high-voltage equipment, such as repair and test benches. Use care that you do not let metallic chips, loose solder, or small parts fall on the matting. This metal will, in time, reduce the insulating value of the matting.

DO NOT WORK ALONE on or near HIGH VOLTAGE. Station a helper where he can see you and where he can reach the main switch quickly in case of an emergency. Furthermore, all personnel should know the proper treatment for electrical shock. Remove your jewelry before you work on this equipment. Keep your clothing closed so that zippers, etc. cannot contact a high-voltage terminal.

Exercise (005):

1. In situations 1 through 3 at the end of this chapter, identify the safety violations pertaining to working with live circuits and state the safety precaution(s) that should be observed.

006. Given selected work situations dealing with the use of tools and test equipment, identify the safety violations and state the safety precaution(s) that should be observed.

Tools. Tools can be separated into many types, such as relay adjusting tools, punching tools, wrenches, etc. Our major groupings for this section are: using tools and preparing tools for storage.

Using tools. You must never hold tools such as drills and screwdrivers at an angle. To keep from breaking them, hold them upright. For the same reason, don't twist them with a pair of pliers or pry with them. Do not hold drills in one position until the bit is overheated. Excess heat weakens the metal. Move it in against the object and then pull it back to let it cool momentarily.

Do not use pliers on a nut because you will ruin the nut. This practice may also strip the plier jaws. You will break pliers if you use them as a bar for prying against objects. Use a minimum of strength when twisting pliers to adjust relay components because excessive strength can break the components. "Light fingers" are required when using all relay adjusting tools.

Wrenches should be pulled toward you. Use the correct size wrench to prevent damage to the nut being loosened. A pipe should not be used as an extension to the wrench handle because it puts extra pressure on the jaws and may also break the wrench.

Never cut into nails with a saw. Also, do not twist a saw to flip off strips of waste material. This act may warp the blade or bend the teeth.

Place a canvas or some type of "catchbasket" between your high level work area and the operating equipment below before beginning to solder or use tools. Take care that your work is done at a safe speed and that you don't overstretch. Otherwise, the work may be of poor quality, or you may fall from your position.

Preparing tools for storage. Metal tools should be coated with a rust-preventive compound and stored in a dry place. Also, tools should not be tossed together in a toolbox. Keep them in divided units or place them on support racks. Provide protective containers for devices such as hydrometers. The hydrometer should be stored near the battery bank and be cleaned and dried after use. When you remove a tool from storage, inspect it for damage before you use it and wipe it with a dry rag to remove the rust-preventive compound.

Test Equipment. Prevent damage to electronic equipment by pulling the unit gently from its storage container. Withdraw it by taking it out straight. Use gloves when you are carrying heavy equipment and equipment with rough edges.

After you remove the test unit from the container, inspect it visually for evidence of corrosion, broken control knobs, a bent pointer, cracks, missing screws, or frayed cords. Before using the instrument, read the operating instructions and note the precautions that apply to it. For example, if you are planning to test a direct current circuit, make sure that you do not connect with a component having alternating current. KNOW YOUR TEST EQUIPMENT AND THE CIRCUITS FOR WHICH YOU ARE RESPONSIBLE.

Inspect the test instrument for electrical operation. Check for the following in this inspection:

a. Absence of pointer movement when voltage is applied to a completed meter circuit.

b. Pointer movement to an improper position. To illustrate, during the ZERO adjustment procedure, the pointer fails to move to zero.

c. Pointer fluctuation.

When using the test equipment, show respect for the electrical voltages present. If a second repairman is available, use him as a safety observer. Comply with the technical orders that apply to the test equipment and to the equipment being checked. Obey all safety directives pertaining to the use of electronic equipment.

Return the test instrument to its storage case when finished. Do not force it into position if you meet resistance. Look for a device that is improperly positioned. Remember: test sets are delicate, expensive, precision instruments. Treat them with care.

Exercise (006):

1. In situations 1 through 3 at the end of this chapter, identify the safety violations of the use of tools and test equipment and state the safety precaution(s) that should be observed.

007. Given selected work situations dealing with the use of ladders, identify the safety violations and state the safety precaution(s) that should be observed.

Ladders. There are likely to be several types of ladders in a central office. In most Strowger exchanges the trolley type is normally found while the A-type is found in most XY exchanges. Regardless of the type, you must observe certain basic practices.

Those that have wheels present an obvious must; you must be able to keep them from rolling. The trolley type has a brake assembly that is mounted in the channeling that holds it upright. The A-type has wheels that are springloaded. That is to say that it will roll when nothing of sufficient weight is on it. When someone is on it, the springs compress and allow the feet of the ladder to rest on the floor.

Everybody knows that you shouldn't walk under a ladder, but have you ever done it just to prove to yourself that you could do it without getting hurt? Probably, but as the songwriter put it, "Your day will come." It's also taken for granted that most folks know not to stand on the top step of a ladder, but, if you'll watch, you'll see it being done and not necessarily by a dummy. Some people also try to save time by not moving a ladder; they lean just a little farther to reach what they want. By doing this sort of thing, not only are you likely to get hurt, but you become a statistic, your supervisor must fill out a ream of paperwork, and the ground safety people get upset. Remember, "Crime doesn't and Safety does" pay.

Now let's talk about crime. You've heard the phrase, "It's a crime," when something unpleasant happens to someone. It's people like us who are responsible. Do you leave things on ladders? Think carefully before you give out with a self-righteous "No." Not even for just a minute? Every now and then we all do. And because we do, people are being hurt. It's very easy to leave a piece of test equipment or a couple of tools resting on one of the ladder's steps or on top of an A-type ladder when you are going to be gone for just a minute to get or do something. Often, somebody needs the ladder while you're gone. If what has been left on the ladder doesn't fall on that person, it falls on the floor and breaks.

Exercise (007):

1. In situations 1 through 3 at the end of this chapter, identify the safety violations pertaining to working with ladders and state the safety precaution(s) that should be observed.

008. Given selected work situations dealing with the use of solvents and lubricants, identify the safety violations and state the safety precaution(s) that should be observed.

Solvents. You have dealt with solvents almost all of your life. From the time you were first able to get around you were told to stay away from them or to be extremely careful when you use them. But you have learned to live with them and normally are pretty complacent about them. At home you have such solvents as drain openers and household ammonia. In the central office you can find some of the same things; but you will also find specialized solvents.

Trichloroethane or trichloroethylene. This solvent, often called trichlor, is a liquid used to clean switching equipment. Cleaning switches is a job that is not done as often today as it used to be. As with anything else that is done infrequently, people forget certain things, and, thus, have accidents. Trichloroethane is practically nonflammable at normal temperatures, and it is a good equipment cleaner. However, it does have its drawbacks; it is toxic. If a person inhales the fumes, he can suffer loss of appetite and headaches, nausea, or even complete stupor. Just the odor of trichlor would make the average person avoid inhaling the fumes; but there are times when you must be exposed to it. Theoretically, it is used only in well-ventilated areas. The problem is that we have exchanges that need to operate in a controlled atmosphere and well-ventilated places to work in an exchange are almost impossible to find. There are some simple precautions we can take.

(1) Use a small fan to blow the fumes away from you.

(2) Work with trichlor for short periods of time and have someone check on you periodically for any telltale symptoms.

(3) Keep the container covered, except when you need to get into it.

(4) Watch for a feeling of nausea or dizziness.

These simple precautions should allow you to get the job done with little or no chance of ill effects to you or your coworkers.

Lubricants. We don't use lubricants as often as we used to. We use to lubricate all the switches in our exchanges completely every 90 to 180 days. This interval, thanks to newer lubricants and the findings of maintenance personnel, has been extended to periods of up to 3 years. Because of the decrease in switch oiling, you are probably unfamiliar with the task. You know that you should use tech data whenever you perform maintenance; it's the law!

Have you ever noticed that when you use oil for any reason it gets spilled? These spills create two possible accident causes: oily rags and slick spots on your floor.

Because people don't watch where they are going when they are in familiar surroundings, they won't see a slick spot on the floor. Therefore, to avoid a serious accident, you must wipe up spills quickly and thoroughly. Then, you should dispose properly of oily rags to avoid a fire started by spontaneous combustion or a spark from a cigarette, cigar, or pipe.

With just a little care on your part, you can prevent many accidents. Properly disposing of rags, properly storing lubricants, and wiping up your spills promptly go a long way toward making your shop a safe shop.

Exercise (008):

1. In situations 1 through 3, at the end of this chapter, identify the safety violations pertaining to working with cleaning solvents and lubricants and state the safety precaution(s) that should be observed.

2-2. A Place for Everything

A place for everything and everything in its place. This maxim isn't just an old cliche; it's also a good motto for today, particularly in a shop environment.

009. Given selected maintenance situations, identify the safety hazards due to poor or improper housekeeping and state the safety precaution(s) that should be observed.

You would think that at our age, over 18 that is, we would, through habit alone, keep our work environment neat and clean. Do you? Take a look around your exchange the next time you have a spare minute.

Are all the tools either in use or in their proper places; how about the test equipment? Are the dust covers on the equipment properly; if not, is it because someone is working on the equipment? If a dust cover is off, is it in the aisle where it can be damaged, or is it stored properly? Let's look further. Are rags, cleaning solvents, lubricants or miscellaneous hardware laying about on or under the workbench? What does the floor look like? In your tour of the exchange, did you have to step over or around trash, tools, test equipment, or TOs that should not have been there? Were there any slick spots on the floor caused by some spilled liquid, such as oil, coffee, or coke? We have only scratched the surface, but by now you probably have a good idea of what we are talking about.

Tools, tech orders, and test equipment have no business on ladders or in the aisles once the work has stopped. Also, they should not be left laying on a bench once the job is done. If we put our equipment away when we are through working, we not only eliminate a possible accident, we also know where to find the equipment the next time we need it.

Equipment dust covers are helpful because they cut down equipment problems due to dust and dirt in the air, but if you've ever stumbled over one, you probably had a few choice words for it and the person who left it there. Putting things in their proper places is essential to a safe shop.

The disposal of oily or dirty rags and the storage of flammable liquids is of considerable concern to all of us. Fire not only destroys millions of dollars worth of buildings and equipment each year, but it also claims thousands of lives. Simple measures, such as storing flammable liquids in an outside storage area and putting rags in a can with a self-closing lid, reduce the chance of fire.

Trash on the floor and slick spots due to spilled coffee, water, wax, etc., in combination with a person in a hurry, form a potential broken back, arm, or worse. Small scraps of wire in and around the main distributing frame (MDF) is probably the biggest source of central office trash on the floor.

Housekeeping is important to you and the people you work with. It not only makes your exchange a safer place, but it makes your job easier because no major cleanup is ever necessary.

Exercises (009):

1. State the safety hazards due to poor housekeeping present in situations 1 through 3 and state the precautions(s) that should be observed.

Situation 1

Sgt Johnson went to the power board in response to a major alarm. He found a blown 1-amp indicator alarm-type fuse that was in parellel with a 150-amp cartridge fuse. Sgt Johnson realized that the cartridge fuse had blown, causing the 1-amp fuse to blow. He went immediately to the bench stock and got replacement fuses of the proper ratings, as both fuses needed to be replaced. He then went to the workbench, got an insulated fuse puller and a screwdriver, and went to the power board and replaced the fuses. When he was done, he returned the tools to their proper places.

Situation 2

AIC Smith went to run a jumper on the MDF. The cable pair was high on the vertical, a little higher than eye level. He routed the jumper and connected it to the horizontal terminal block. He then stripped the insulation from the jumper and proceeded to connect it to the protector with the wire wrap gun. While Airman Smith was in the process of terminating the jumper, the barrel of the wire wrap gun touched the terminals just beneath those he was working on.

Situation 3

Airman Jones was told by his supervisor to clean and lubricate the switches in linefinder bay 1. Airman Jones went to the TO cabinet and removed the workcard tech order he needed. After he found the section dealing with switch cleaning and lubrication, he gathered up the necessary materials for the job.

After he had obtained all the materials, he set up an area at the workbench and went to get the first switch. Because he found that it was at the very top of the equipment bay, he went to get a ladder. After he moved two dust covers out of the aisle, he positioned the ladder so that he could get to the linefinder switch he needed. After he removed the switch he put the wrench and screwdriver on the top step of the ladder. When he returned to the bench, he started cleaning and lubricating the switch in accordance with the TO instructions.

Shortly after he started the job, one of his friends asked him to go to coffee, and he did, promptly. When he returned from his coffeebreak, he found an oily rag in the work area and all the containers tightly capped.

When he asked his supervisor why somebody had been messing around in his area, he was told that someone had accidentally knocked over the bottle of oil. Airman Jones then returned to cleaning and lubricating linefinder switches.

NOTE: **Chapters 3,4, and 5, have been deleted due to military specific materials.**

CHAPTER 6

Electronic Principles

THE TELEPHONE is neither a novelty nor a luxury in our present world. For our fast-moving civilization it is a necessity. Our entry into the age of satellites has increased the need for speed and accuracy in communications. As a result, the complexity of communications systems has also increased. Therefore, your knowledge must expand or broaden for you to be able to maintain such equipment systems. To gain recognition and advancement in your telephone switching systems career field, you must study many related telephone systems.

Accurate, high-quality telephone systems depend on electricity. In addition, many of the testing units for which you are responsible work on electrical principles. You can see, then, why a chapter about electrical fundamentals is valuable. Furthermore, during your study of the other CDC volumes that contain descriptions of equipment circuits, you may need to refer to these circuit principles.

6-1. Terms

A technician in any career field must be able to communicate with men in his own and allied fields. When technicians talk about their work, they use terms that are job related. They use electrical terms and symbols when they are presenting a circuit to simplify the presentation and permit a more rapid understanding of the circuit principles.

053. Given a list of electrical terms, match them to the proper explanation.

Electrical Terms. We know that there are many terms that apply specifically to electrical circuit descriptions. However, it is not necessary that we mention every term because many are familiar to any electrical systems repairman, whether he works with automotive electrical systems, building electrical systems, radio systems, or telephone systems. You have seen the terms that we are listing before in the resident course study materials.

Decibel (db). This term is a unit for expressing power ratios in electrical circuits. For example, 0 db can indicate a power ratio of 1; in this case, 10 db equals a power ratio of 10, and 20 db equals a power ratio of 100. Consequently, 30 db would equal a ratio of 1000. Zero db can be used to indicate a current or voltage ratio of 1, but in this relationship 10 db indicates a ratio of 3.2. The use of decibels permits you to avoid very large or very small numbers when you are analyzing circuits.

Differential. This results from a difference in quantities or quality. For instance, a differential relay operates or fails to operate because of the difference in current. Current in both windings prevents the relay from operating because of magnetic opposition. On the other hand, current in only one winding causes the relay to operate.

Energized. Energized refers to a condition in which current is flowing in the device; thus, it is operating. This statement may not always hold true because some descriptions specify energized as the condition in which the device has preoperational current; then an additional surge of current follows which operates the device.

Preparing a circuit. You will often find this expression used when the circuit activities of communications equipment are being described. It identifies an action within a circuit which has several open contacts where one part of the circuit has just been closed. However, the operating circuit is not complete until all remaining open contacts are closed.

Resistance battery. Resistance battery is an expression for a circuit arrangement where a resistor or resistance device is connected between the relay and the power unit's terminals. Consequently, during the relay's operation, the current will be less than would be available without the series resistor. Likewise, having a voltage drop across the series resistor results in a smaller voltage reading at the operated relay.

Ringing. Signaling is accomplished by using alternating current. But it is the usual practice also to connect the ringing lead to a battery source, because this connection permits an associated relay to operate to cut off the ringing. A polarized relay or a slow-to-operate relay may do this. In addition, making the AC circuit a low-value current circuit while the DC circuit is developed to have a greater current flow would allow this cutoff operation. You will often see this connecting procedure referred to as superimposed ringing.

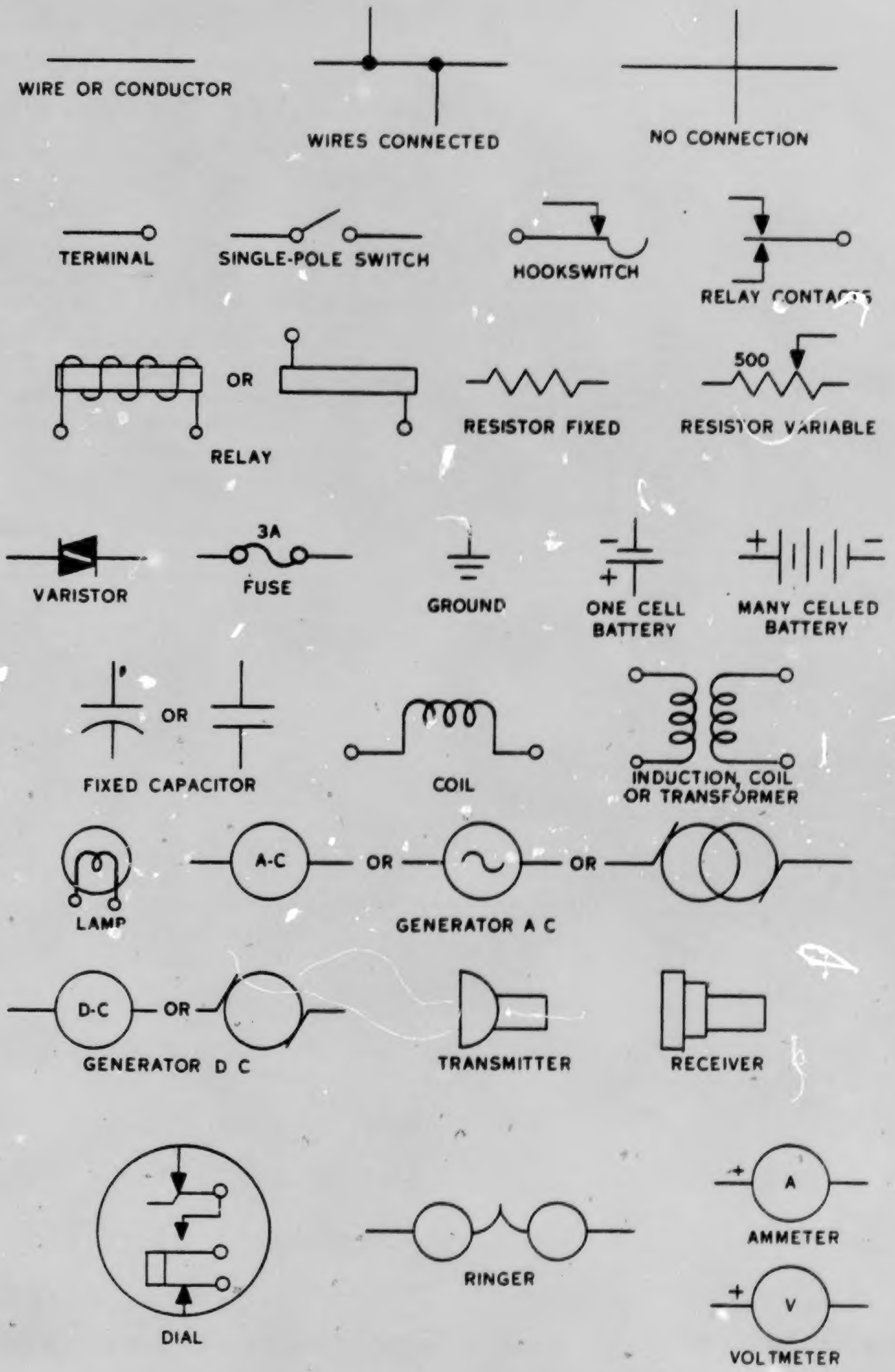


Figure 6-1. Representative electrical symbols.

Exercises (053):

Match the terms and symbols listed on the left with the proper name or explanation listed on the right.

____ 1. Decibel.
____ 2. Ringing.
____ 3. Preparing a circuit.
____ 4. Resistance battery.
____ 5. Energized.
____ 6. Differential.

a. A circuit arrangement where a resistor or resistance device is connected between the relay and the power unit's terminals.
b. Identifies an action within a circuit which has several open contacts, where one part of the circuit has just been closed.
c. Refers to a condition in which current is flowing in the device; thus, it is operating.
d. Signaling accomplished by using alternating current.
e. A unit for expressing power ratios in electrical circuits.
f. Current in both windings prevents the relay from operating because of magnetic opposition. On the other hand, current in only one winding causes the relay to operate.

6-2. Electrical Diagrams and Symbols

You know that there are many diagrams that can be used to simplify circuit analysis. They help you to understand the theory and principles of a telephone circuit and in troubleshooting. Word descriptions are also used with the circuit diagrams to increase your understanding. Diagrams that we will describe are: schematic, wiring, block, line and contact, and ball and chain.

054. Given a list of electrical components and a wiring schematic, identify the schematic symbols which represent the listed components.

Electrical Symbols. Symbols that represent the various electronic devices on electrical equipment schematic diagrams often differ. Figure 6-1 shows some symbols with which you should be familiar. Thinking of each symbol as a part of the circuit and understanding its function makes the circuit analysis easier. As a result, you can determine, locate, and repair trouble more rapidly. NOTE: A capacitor for a circuit could be shown with or without a curved line. Similarly, AC generators can be represented in three ways.

Figure 6-2 shows the relationship of some devices in a circuit for one telephone system. On this figure you can see that the negative of the battery (short line of the battery symbol) is connected to the D terminal for relays CB, RD, and RT. In addition, contacts 1, 2,

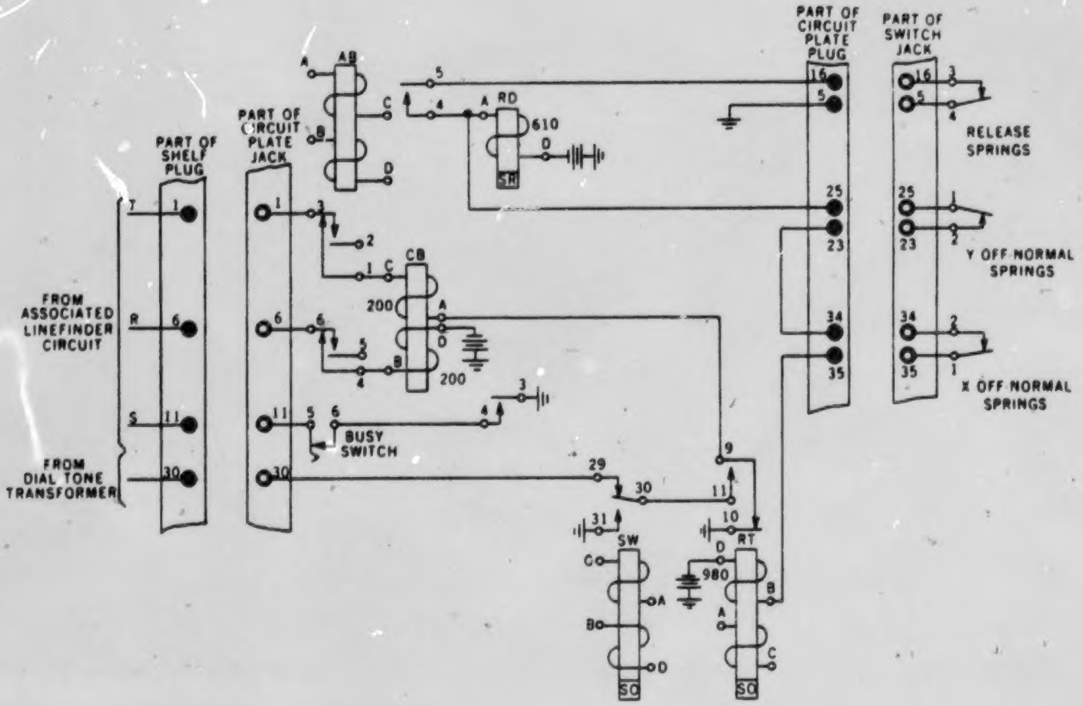


Figure 6-2. Simplified operating circuit for relays CB, RD, and RT.

3, 4, 5, and 6 of relay AB appear directly between relay CB and the circuit plate jack. This appearance is not a true representation of the position because relay AB and its contacts are positioned on the frame at the side of relay CB which is farthest from the circuit plate jack. In other words, relay AB could be more accurately illustrated in the position of relay RD. It is not a good practice to memorize schematic diagrams for circuits because this type of illustration can be misleading. Other symbols for figure 6-1 are comparable to the symbols of the circuit in figure 6-2. For example: straight lines for conductors, large dots that represent wire connections, and conductors that cross without a connection.

Schematic Diagram. This diagram (see fig. 6-2) is used most often to explain the circuit relationships because it makes the circuits easy to trace. The schematic allows emphasis of the important features of the circuit. Conventional symbols are used, but their position or placement does not necessarily correspond to the location of the actual part within the equipment. Since a schematic is not a true picture of an equipment circuit, learn the principles of operation of the devices of the circuit. Frequently, certain small groups of parts form relatively simple units within the complex circuit. For example, a diagram of a complete telephone system can be broken down into a transmitter circuit, a receiver circuit, a ringing circuit, relay circuits, and several other smaller circuits. You should learn to recognize these units and relate them to the others. You should think of each unit in terms of its function in the circuit. Also, try to visualize the actual unit position in relation to its position in the schematic.

Exercises (054):

Using figure 6-2, circle and label one of each of the following components.

1. Relay contacts.
2. Relay coil.
3. Battery.
4. Ground.
5. Wires, connected.

6-3. DC Circuits

In order for current to flow, two things are essential: there must be a source of electrical pressure (voltage), and there must be a complete circuit. The source of voltage may be a battery, a generator, or some other device. The complete circuit requirement means that there must be a complete path from the negative terminal through the load and back to the positive terminal of the source. The complete path should allow the electrons to flow freely to the load, do their work in the load, and then move freely back to the source without straying off into other loads or doing any unnecessary work. However desirable this condition is, it cannot be completely achieved because no conductor (wire) allows the electrons to move with complete freedom. There is always some resistance to the electron flow. All conductors have some resistance; just how much they have depends on the size and length of the conductors, as well as on the materials of which they are made. The source of voltage is any device that has an excess of electrons in one place over the number of electrons in another place. Connecting the two places by means of an electrical circuit, including resistance, permits the two places to try to equalize the number of electrons.

055. State Ohm's law algebraically for voltage, current, and resistance.

Ohm's Law and Direct-Current Circuits. Ohm's law is concerned with three separate properties: voltage, current, and resistance. The relationship between these three properties in an electrical circuit can be stated as:

- Current in any electrical circuit is directly proportional to the applied voltage.
- Current in any electrical circuit is inversely proportional to the resistance.

Mathematically, it is expressed as $I = \frac{E}{R}$. In this formula, I stands for the current in amperes, E for the voltage in volts, and R for the resistance in ohms. For example, figure 6-3 shows that the source of potential is a 6-volt battery and the electrical device is a bulb having 3 ohms of resistance. The current will be $\frac{6}{3} = 2$ amperes. The formula for Ohm's law can be converted mathematically to read as follows: $E = I \times R$. By use of this formula, you can determine the voltage across a component of a circuit if you know the unit's resistance and the current flow through it. For example, if you know that the current through a lamp is 2 amperes and the resistance of the lamp is 3 ohms, then the voltage across it must be 3×2, or 6 volts.

To determine the resistance of a circuit component,

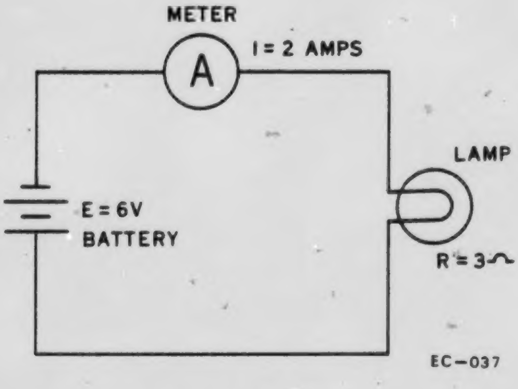


Figure 6-3. Basic circuit.

the formula for Ohm's law can be converted mathematically to read $R = \frac{E}{I}$. Suppose you know that the voltage across a lamp is 6 volts and the current through it is 2 amperes. You can find the lamp's resistance by the use of the formula: $R = \frac{E}{I}$ (or) $\frac{6}{2} = 3$ ohms. Using these three formulas enables you to find any one of three quantities—voltage, current, or resistance—when the other two of the factors are known, regardless of whether the circuit is a series, parallel, or series-parallel circuit.

Exercises (055):

1. State Ohm's law algebraically for voltage, current, and resistance.

056. Given schematic diagrams of DC series-parallel circuits and sufficient values, solve for unknown values of voltage, current, and/or resistance.

Series Circuits. A series circuit is one in which there is only one path through which the current can flow. In figure 6-4, three resistances and a battery are connected to form a series circuit. Since there is but one path for the current, all of the current passes through each resistance and the current is the same throughout the entire circuit. The total voltage drop in the series circuit is equal to the sum of the voltages (voltage drops) across the individual resistors, or $E_T = E_1 + E_2 + E_3$, etc. The total resistance of the circuit is equal to the sum of the resistances of the individual units: $R_T = R_1 + R_2 + R_3$, etc. If one of the devices in a series circuit burns out, there is no longer a complete path for the current; therefore, the other devices in the circuit will not operate.

Problem. In figure 6-4, three resistances are connected in series across a 24-volt power source. The voltages and currents were measured and found to be as indicated in the illustration. Find:

(1) The total voltage drop (E_T).

(2) The total current (I_T).

(3) The resistance of each unit and the total resistance (R_1, R_2, R_3, and R_T).

Solution.

(1) Using the formula $E_T = E_1 + E_2 + E_3$

$$E_T = 8_v + 4_v = 24 \text{ volts}$$

(2) Using the formula $I = \frac{E}{R}$

$$I_T = I_1 = \frac{8v}{4\Omega} = 2 \text{ amperes}$$

Since the current is the same throughout a series circuit, IR_2 and IR_3 are also 2 amperes.

(3) Using the formula $R_T = \frac{E_T}{I_T}$

$$R_1 = \frac{8v}{2a} = 4 \text{ ohms}$$

$$R_2 = \frac{12v}{2a} = 6 \text{ ohms}$$

$$R_3 = \frac{4v}{2a} = 2 \text{ ohms}$$

(4) Now, using the formula $R_T = R_1 + R_2 + R_3$, etc., we find that

$$R_T = 4\Omega + 6\Omega + 2\Omega = 12 \text{ ohms (or) } R_T$$

$$= \frac{24v}{2a} = 12 \text{ ohms}$$

Parallel Circuits. In a parallel circuit, two or more electrical devices provide independent paths through which the current may flow. The voltage across each device so connected in parallel is the same (fig. 6-5),

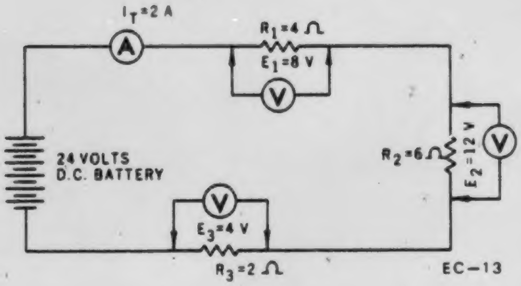


Figure 6-4. Series circuit.

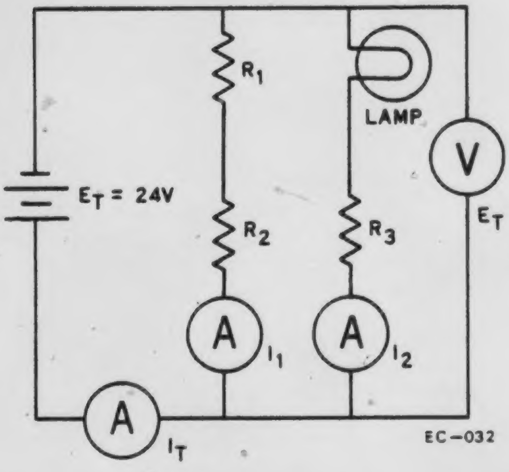


Figure 6-5. Parallel circuit.

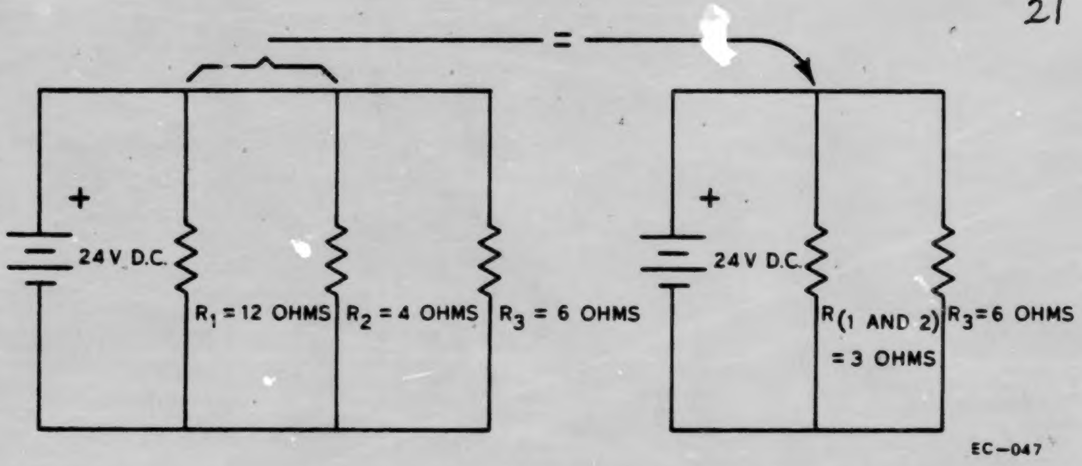


Figure 6-6. Solving parallel circuit.

or $E_T = E_1 + E_2 + E_3$, etc. The total current in a parallel circuit is equal to the sum of individual currents flowing through the parallel-connected devices. In figure 6-5, I_1 is summed with I_2, or $I_T = I_1 + I_2$, etc. The greater the number of electrical devices or resistors connected in parallel in a given circuit, the greater will be the total current and the smaller will be the total resistance of the circuit. Electrical devices are connected in parallel in any installation in order to allow the units to operate independently of each other.

There are several ways to calculate the total resistance of a parallel circuit. We shall show the simpler way first, and then give you the general rule.

To calculate the total resistance of a parallel circuit, use the following formula and solve for the equivalent resistance of only two paths at a time.

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

Problem. In figure 6-6, three load units are connected in parallel. Using the resistance values indicated, find the total resistance.

Solution.

(1) Using the formula for the first two paths

$$R_{(1\text{ and }2)} = \frac{12 \times 4\text{ ohms}}{12 + 4\text{ ohms}} = \frac{48\text{ ohms}}{16\text{ ohms}} = 3\text{ ohms}$$

(2) Since 3 ohms is the equivalent resistance of the first two paths, you may substitute a 3-ohm resistor for them and, adding the 6-ohm resistor of the third path, redraw the circuit as shown at the right in the illustration (fig. 6-6).

(3) Then, combining $R_{(1\text{ and }2)}$ with R_3, you have

$$R_T = \frac{R_{(1\text{ and }2)} \times R_3}{R_{(1\text{ and }2)} + R_3} = \frac{3 \times 6\text{ ohms}}{3 + 6\text{ ohms}}$$

$$= \frac{18\text{ ohms}}{9\text{ ohms}} = 2\text{ ohms}$$

Notice that the equivalent resistance of parallel branches is always less than the smallest branch resistance.

The general formula for finding the total resistance in a parallel circuit is

$$R_T = \frac{1}{\frac{1}{R_1}\ \frac{1}{R_2}\ \frac{1}{R_3}}$$

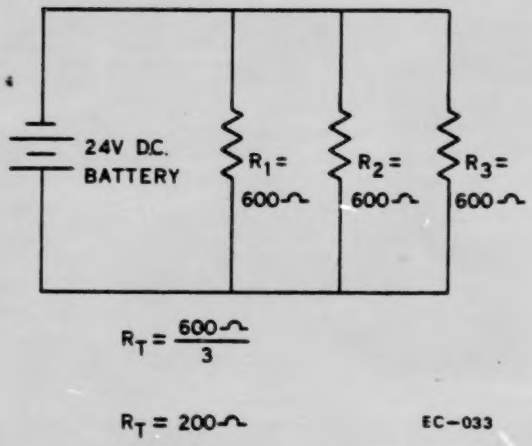


Figure 6-7. Identical parallel resistances.

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Now, using the following formula, the total resistance can be computed as

$$R_T = \frac{1}{\frac{1}{12} + \frac{1}{4} + \frac{1}{6}} = \frac{1}{\frac{6}{12}}$$

$$= \frac{1}{1} + \frac{6}{12}$$

$$= \frac{1}{1} \times \frac{12}{6} = \frac{12}{6} = 2 \text{ ohms}$$

When the load units that are connected in parallel all have the same resistance value (fig. 6-7), the previous equation may be simplified to read

$$R_T = \frac{\text{resistance of one unit}}{\text{number of like units}}$$

or

$$R_T = \frac{R}{N}$$

Series-Parallel Circuits. As shown in figure 6-8, in a series-parallel circuit, some of the units are connected in series with each other, while other units are connected in parallel. To solve a series-parallel problem, first convert it to a series circuit by substituting an equivalent resistance for the parallel resistances; then solve the series circuit problem as explained previously.

Problem. In the illustration of the series-parallel circuit (fig. 6-8), a resistor is connected in series with four lamps which are connected in parallel with each other. The voltages and resistances were measured and found to be as indicated. Find the current through the various parts of the circuit.

Solution.

(1) Since the resistance of each lamp is 4 ohms, using the formula, $R_T = \frac{R}{N}$, the equivalent resistance of the four lamps in parallel is computed as

$$R_T = \frac{4 \text{ ohms}}{4} = 1 \text{ ohm}$$

(2) Substituting a 1-ohm resistor for the four lamps and using the formula $R_T = R_1 + R_2$, you will find the total resistance of the circuit is

$$R_T = 5 + 1 = 6 \text{ ohms}$$

(3) Now, using the formula $I = \frac{E}{R}$, you can compute the total current in the circuit

$$I = \frac{24 \text{ volts}}{6 \text{ ohms}} = 4 \text{ amperes}$$

(4) Since the total current must flow through the series resistor, the current flow through it must be 4 amperes.

(5) Since the total of the currents flowing through the four lamps is 4 amperes and since they all have the same value of resistance, the current must divide evenly among the lamps and is therefore, found to be 1 ampere through each lamp circuit.

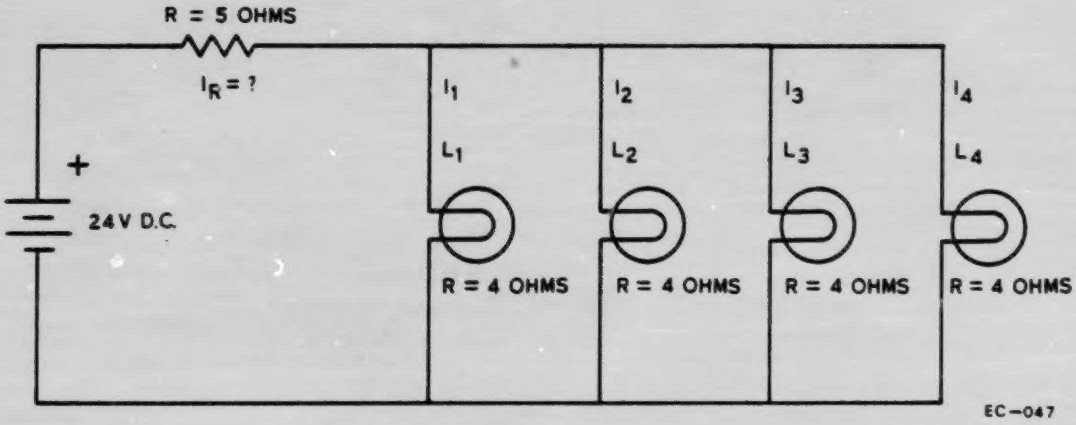

Figure 6-8. Series-parallel circuit.

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Exercises (056):

Using the schematic drawings and values given, solve for unknown values of voltage, current, and resistance.

1. Figure 6-3; I = 4 amps, R = 20 ohms, E = ______.

2. Figure 6-5; E_T = 24 volts, I_T = 6 amps, R_T = ______, I_1 = 4 amps, I_2 = ______, $R_1 + R_2$ = ______, lamp + R_3 = ______.

3. Figure 6-8; E_T = 100 volts, I_T = ______, L_1 = 30 ohms, I_1 = 2.5 amps, L_2 = ______, I_2 = 1.5 amps, L_3 = 100 ohms, I_3 = ______, L_4 = ____, I_4 = .25 amps, R_T = ______.

4. Figure 6-4; E_T = 24v, E_1 = 2 volts, R_2 = 6 ohms, I_T = .5 amp.
   R_1
   E_2
   R_3
   E_3

5. Figure 6-6; E_T = 30v, I_1 = 1.5 amps, R_2 = 300 ohms, I_T = 5amps
   R_1
   I_2
   R_3
   I_3
   R_T

6-4. Principles of AC

The main source of electrical power used throughout the world is the alternating-current generator. The principle reason for this is that less power is lost in transmitting alternating current at high voltage and low current than in transmitting direct current of comparable power. Alternating voltage can be stepped down to a suitable value at the user's end of the line.

Remember that in a DC circuit, current moves in one direction: from the negative terminal of the source through the circuit to the positive terminal. In AC circuits, the current moves first in one direction and then in the opposite direction; this is where we get the term "alternating." For our first discussion, let's get an understanding of how AC is generated.

057. Given either the frequency, period, or wavelength of a sine wave, compute the other values.

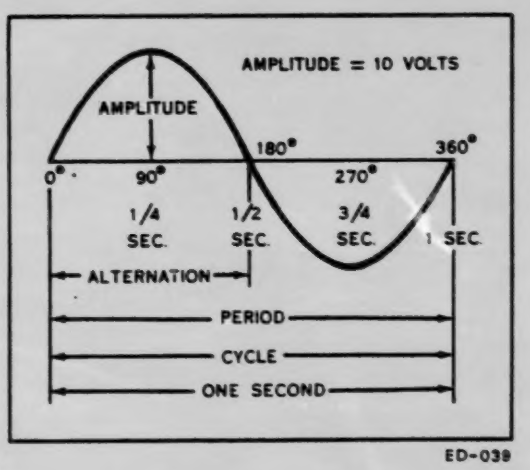
Generation of AC. You should remember from your 3-level resident course that there are three factors necessary to generate a voltage: a magnetic field, conductors, and relative motion between the field and the conductors. All mechanical generators are applications of this principle. On the DC generator the output is taken off through an arrangement of brushes on a commutator. This arrangement provides for current always leaving the generator through the same brushes. If the output of a DC generator were viewed on an oscilloscope, it would appear as an almost straight line.

An AC generator operates basically the same way as does a DC generator. The exception is that instead of a commutator, the AC generator (alternator) has sliprings on which the brushes ride and connect to an external circuit. With a slipring arrangement, the current from the rotor will go out one set of brushes for a period of time and then out the opposite set of brushes for an equal period of time. If the output of a simple alternator were viewed on an oscilloscope, the output would appear as shown in figure 6-9.

Cycle. The output from zero to maximum and back to zero in one direction is termed an alternation. Two alternations, one in each direction, are referred to as one cycle. The number of cycles per second (cps) is referred to as the frequency. You should remember also that cycles per second are referred to as Hertz (Hz).

Amplitude. This term expresses the maximum amount an AC voltage varies above or below a reference value. (See fig. 6-9.)

Period. The time required to complete 1 cycle of voltage or current variation is the period. If it takes 1 second, as is indicated in figure 6-9, to generate 1



ED-039

Figure 6-9. Alternator output waveshape.

cycle of the sine wave voltage, the period is 1 second. The common symbol used to represent the period is T.

Frequency. The number of cycles occurring in 1 second of time is called the frequency, and it is denoted by the symbol f. The relationship between the period (T) and the frequency (f), from the definitions, can be stated as:

$$f = \frac{1}{T}$$

or

$$T = \frac{1}{f}$$

If the period of 1 cycle is 0.1 second, the frequency is 10 cps or 10 Hz. Likewise, if a million Hz voltage is applied to a circuit, the cycle is completed in one-millionth of a second:

$$T = 0.000001 \text{ or } 1 \times 10^{-6}$$

Wavelength. In electronics, the term "wavelength" is defined as the number of meters an electromagnetic wave travels in the time of one cycle. One meter equals 39.37 inches.

There is a definite relationship between wavelength, frequency, and time period of a cycle. You can find the time period if you know either the wavelength or the frequency. Figure 6-10 shows the relationship of these three units of measure.

As you can see, figure 6-10 shows sine waves of AC with a frequency of five cycles in one second. The period of one cycle is one-fifth of a second. Notice that the relationship of the wavelength to the distance traveled in one second is the same as the relationship of the period to one second.

The important thing to remember is that if either the wavelength, frequency, or period of an AC is known, you can find the other two. If either the wavelength or period is known, you can find the frequency by dividing the wavelength into three hundred million or the period into one second. If the frequency is known, you can find the wavelength by dividing three hundred million by the frequency,

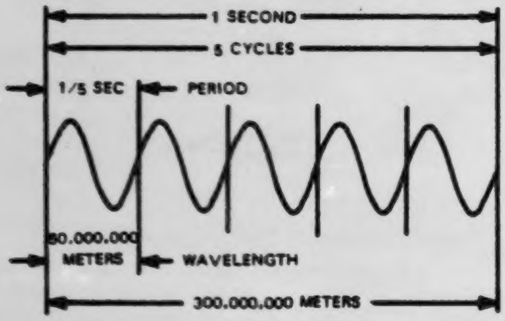


Figure 6-10. Relation of wavelength, frequency, and period.

$$\text{wavelength} = \frac{300{,}000{,}000}{f}$$

or you can find the period by dividing one second (or 1,000,000 microseconds) by the frequency. If you know the wavelength, you can find the period by dividing the wavelength by three hundred million.

Exercises (057):

Using the formulas in this segment, compute the unknown values.

1. f = 50 hertz; T = 20 milliseconds, wavelength = ________ .

2. f = ________ ; T = 250 microseconds, wavelength = ________ .

3. f = ________ ; T = ________ , wavelength 60 meters.

4. f = 50 kHz; T = ________ , wavelength = ________ .

5. f = _____ ; T = ________ , wavelength 750 meters.

6. f = _____ ; T = 4 milliseconds, wavelength = ________ .

6-5. Operation of Reactive Circuits

Many of the circuits in our switching equipment contain reactive components, such as capacitors and inductors (relay coils and transformers). The cable pairs connected to our distributing frame have a certain amount of capacitance and inductance.

These reactive components and properties affect our circuits in one way or another. Let's briefly discuss reactive components and how they affect a circuit.

058. State the effect of each variable on the amount and angle of current in a series RL circuit with an AC voltage applied.

Inductance. In the analysis of resistive circuits, any opposition to electrical current is termed resistance. The current in a coil may be compared to an object in motion, such as an automobile, which is retarded by wind resistance and by friction between the tires and the surface of the road. With a constant voltage applied, current through a coil is limited only by the resistance of the coil wire. If, however, the current through a coil is interrupted suddenly, by opening a switch, for instance, a considerable spark will jump the contacts of the switch as it opens. This spark occurs because of the fact that when DC was applied to the coil a magnetic field was developed. When the field is building the lines of magnetic force, cutting the conductors of the coil generates a counter electromotive force in the coil in opposition to the applied voltage. When the circuit is opened, the magnetic field collapses across the coil and generates a surge of voltage with a polarity that aids the applied voltage.

When an alternating current flows through a coil of wire, it sets up an expanding and collapsing magnetic field about the coil. The expanding and collapsing magnetic field induces a voltage within the conductor proper. This results in the self-induced voltage tending to keep a current moving when the applied voltage is decreasing and to oppose a current when the applied voltage is increasing. This property of a coil which opposes any change in the current flowing through it is termed inductance.

From the fact that a coil in a circuit opposes any change in current, you can reason that maximum current through the coil will occur sometime after the applied AC reaches maximum potential. As the applied voltage is increasing, the coil's induced voltage is opposing the applied voltage. As the applied voltage alternation is decreasing, the coil's induced voltage is such that it is aiding the applied voltage. This reaction by the coil causes the current in an inductive circuit to lag the voltage.

The inductance of a coil is measured in henrys, and the symbol for inductance is L. In any coil, the inductance depends on several factors: the number of turns of wire in the coil, the cross-sectional area of the coil, and the material in the center of the coil or the core. A core of magnetic material greatly increases the inductance of the coil. Remember, however, that even a straight wire has inductance, small though it may be when compared to that of a coil. All AC motors, relays, transformers, and the like contribute inductance to a circuit.

To calculate the total inductance of coils connected in series you use the formula:

$$L_t = L_1 + L_2 + L_3, \text{etc.}$$

To calculate the total inductance of coils connected in parallel you use the formula:

$$L_t = \frac{1}{\frac{1}{L_1}\ \frac{1}{L_2}\ \frac{1}{L_3}} + \cdots$$

Inductive Reactance. The opposition to current which inductance causes in an AC circuit is called inductive reactance. Inductive reactance is measured in ohms and is represented by the symbol X_L. In any circuit in which there is resistance only, Ohm's law expresses the relationship between voltage and current. Similarly, when there is inductance only in an AC circuit, the relationship between voltage and current can be expressed by a modification of the equation as

$$\text{Current} = \frac{\text{voltage}}{\text{inductive reactance}}, \text{or } I = \frac{E}{X_L}$$

The greater the inductance of a coil, the greater will be the opposition to change of current. Also, the higher the frequency, the greater the reactance; since the greater the rate of current change, the more opposition the coil offers to the change. Therefore, inductive reactance is proportional to the inductance and frequency, or

$$X_L = 2\pi \times f \times L$$

In this equation, f is the frequency in hertz, L is the inductance in henrys, and 2π is a constant equal to 6.28 which remains the same regardless of changes in the other factors involved. In a circuit containing both resistance and inductive reactance, you do not determine total opposition to current by merely adding X_L to R arithmetically. This must be done vectorially because the phase angle between the current and voltage is different in each type of component in an AC circuit. The vectorial addition can be done graphically, by the use of Pythagorean theorem, or trigonometrically. The resultant value is a combination of two different types of opposition and cannot truly be called resistance or reactance. The combined opposition to current in an AC circuit is termed impedance and is represented in electrical formulas by the letter Z. If the total current in an AC circuit is known, you may find the total opposition by using the formula $Z = \frac{E}{I}$.

Exercises (058):

1. Name the two factors that affect the value of X_L.

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2. What happens to the value of X_L, if the frequency of applied AC is increased?

3. What happens to AC current through a coil, if the frequency of the applied voltage is lowered?

4. What happens to AC current through a coil, if a second coil is added in series with it?

5. What happens to total current in an inductive circuit, if another coil is added in parallel?

6. If the value of R in a series RL circuit is increased, what happens to the angle between total current and applied voltage?

7. What happens to the amount of current in a series RL circuit when
   a. R is increased?

   b. L is increased?

   c. f is increased?

059. State the effect of each variable on the amount and angle of current in a series RC circuit with an AC voltage applied and tell how frequency can be changed for certain effects.

Capacitance. Another important property of AC circuits, besides resistance and inductance, is capacitance. Any two conductors separated by a nonconductor form a capacitor. In an electrical circuit, a capacitor serves as a storage place for electricity. When you connect a capacitor across a source of direct current, such as the battery indicated in figure 6-11, and close the switch, plate B becomes positively charged and plate A becomes negatively charged. There is current in the external circuit during the time the electrons are moving from plate B to A. The current in the circuit is maximum at the instant you close the switch and it continually decreases until it reaches zero.

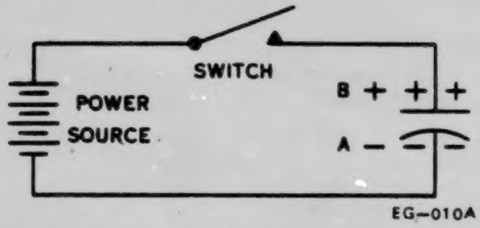


Figure 6-11. Capacitor in a DC circuit.

The current decreases to zero when the difference in voltage between plates A and B becomes the same as the voltage of the charging source (battery). If you open the switch, the plates will remain charged. However, when the capacitor is short-circuited, it quickly discharges. The amount of electricity a capacitor can store depends on its plate area, the distance between the plates, and the material in the dielectric (the insulation between the plates). The capacity is directly proportional to the distance between the plates.

If a source of alternating current is substituted for the battery, the capacitor acts quite differently from the way it acts with direct current. When an alternating current is impressed on the circuit, the charge on the plates constantly changes. This means electrons must first flow from Y (in the diagram in fig. 6-12) clockwise around to X, then from X counterclockwise around to Y, then clockwise from Y around to X, and so on. Although there is no current through the insulator between the plates of the capacitor, it flows constantly in the remainder of the circuit between X and Y. In a circuit where there is only capacitance, the current leads the applied voltage, as contrasted with a circuit in which there is only inductance, where the current lags the voltage. Figure 6-13 shows the relationship of these conditions.

Capacitance is symbolized by the letter C. The unit of measurement for capacitance is the farad, for which the symbol is f. The farad is too large for practical use, and the units more generally used are the microfarad (mf), one-millionth of a farad, and the micromicrofarad (mmf), one-millionth part of a

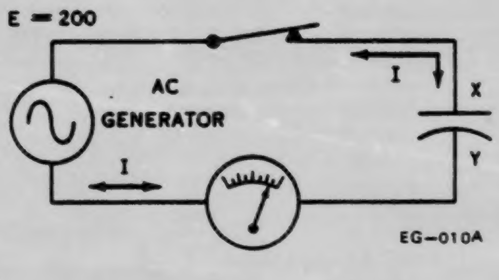
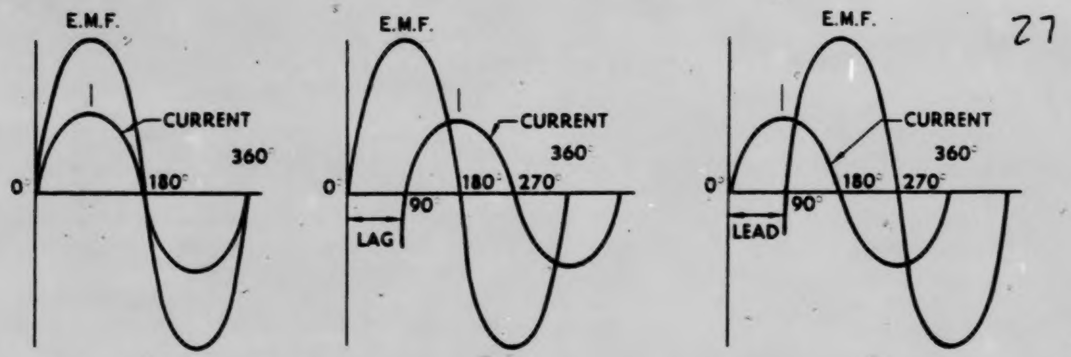


Figure 6-12. Capacitor in an AC circuit.



A. CURRENT AND VOLTAGE IN PHASE

B. EFFECT OF INDUCTANCE

C. EFFECT OF CAPACITANCE

Figure 6-13. Current and voltage phase relations.

microfarad. To shorten the writing of a micromicrofarad, most electronics personnel are beginning to use the term "picofarad" (pf).

In order to obtain desired values of capacitance in a circuit, capacitors are frequently connected in parallel and sometimes in series with each other. Physically, capacitors may be placed quite close together without affecting each other to any great extent. If more capacitance is desired than is available in one single capacitor, several units may be connected together in parallel. When this is done, the total capacitance of the combination will be the sum of the individual capacitances. Capacitors, when connected in series, will have a total capacitance that is less than that of the smallest capacitor in the series combination. The total capacitance for a combination of capacitors in series can be computed by the equation

$$C_t = \frac{C_1C_2}{C_1 + C_2}$$

Capacitive Reactance. Capacitance, like inductance, offers opposition to AC. This opposition is called capacitive reactance, and it is measured in ohms. The symbol for capacitive reactance is X_C. Ohm's law can now be modified to read

$$\text{Current} = \frac{\text{voltage}}{\text{capacitive reactance}}, \text{ or } I = \frac{E}{X_c}$$

which is similar to the equation for current in an inductive circuit. The value of capacitive reactance depends on the capacitance and the frequency of the applied voltage; it varies inversely with both the capacitance and the frequency. In a circuit containing only capacitance, the greater the capacitance, the less the reactance (opposition); and the greater the frequency, the less the reactance. Hence, the equation for capacitive reactance is expressed as

$$X_c = \frac{1}{2\pi \times f \times C}$$

to find again, as in RL circuits, total opposition is a RC circuit reactance and resistance must be combined vectorially.

Exercises (059):

1. Is current leading, lagging, or in phase with voltage, when AC is applied to a capacitor?

2. How should the frequency of applied AC be changed to cause increased current in a purely capacitive circuit?

3. What is the effect on total opposition to AC in a capacitive circuit, if another capacitor is added in parallel?

4. If the frequency of AC applied to a series RC circuit is increased, what happens to value of
   a. R?
   b. X_C?
   c. Z?

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5. What happens to the angle between applied voltage and total current in a series RC circuit, if the value of R is increased?

6. What happens to the amount of current in a series RC current when
   a. C is increased?
   b. f is increased?

6-6. Principles of Solid State Devices

The use of semiconductor rectifiers in power supplies for electronic equipment is increasing. Their advantages are: immediate operation without need for warmup time, low internal voltage drop substantially independent of load current, low operating temperature, and small physical size. Formerly, metallic or dry-disc rectifiers, such as copper-oxide, copper-sulfide, and selenium rectifiers, were used primarily in low-voltage applications and were limited in use to the lower frequencies (25 to 800 hertz). Additional design improvements have allowed these rectifiers to be used with higher input voltages, and today they are widely used as power rectifiers. The newer silicon-type rectifier is now used in many power-supply circuits where other types were formerly used. The small physical size of semiconductor rectifiers, especially the silicon types, makes it practical to place these units in series to handle high input voltages.

060. Describe the effects of applying DC and AC voltages to PN junctions, and name the majority carrier in the N and P types of semiconductor material.

PN Junctions. In the 3-level resident course you learned that in the manufacture of solid state devices impurities were added to cause the material to be either P-type or N-type. In the N-type of material, the electrons are the majority carriers, and, in the P-type of material, the holes are the majority carriers. In both types of materials, current in the external circuit consists of electrons moving out of the negative terminal of the battery through the crystal and into the positive terminal of the battery.

A semiconductor diode is manufactured by a chemical process where donor impurities are added to one region of a crystal and acceptor impurities are added to the other section of the crystal. This gives a single crystal with an N section and a P section. The area where the N and P section are joined is called a junction. The result is a PN junction or junction diode. Metallic contacts are bonded to the two ends of the crystal to form a circuit connection to the crystal.

The polarity of the voltage applied to a PN diode will determine whether or not the diode will conduct. If the negative terminal of the battery is connected to the N material and the positive terminal is connected to the P material, the diode is considered to be forward biased. With this condition maximum current will flow through the diode. If the power supply leads to the diode are reversed, the diode is considered to be reverse biased. With the diode reverse biased, a negligible amount of current will flow.

Rectifiers. A diode placed in an AC circuit is alternately forward biased and reverse biased. Since current flows more readily in one direction than the other, the diode acts as a rectifier.

Half-wave rectifiers. The single-phase, half-wave rectifier is the simplest type of rectifier circuit. It consists of a semiconductor diode in series with the alternating source and the load. Since the rectifier conducts in only one direction, electrons flow through the load and through the rectifier only once during

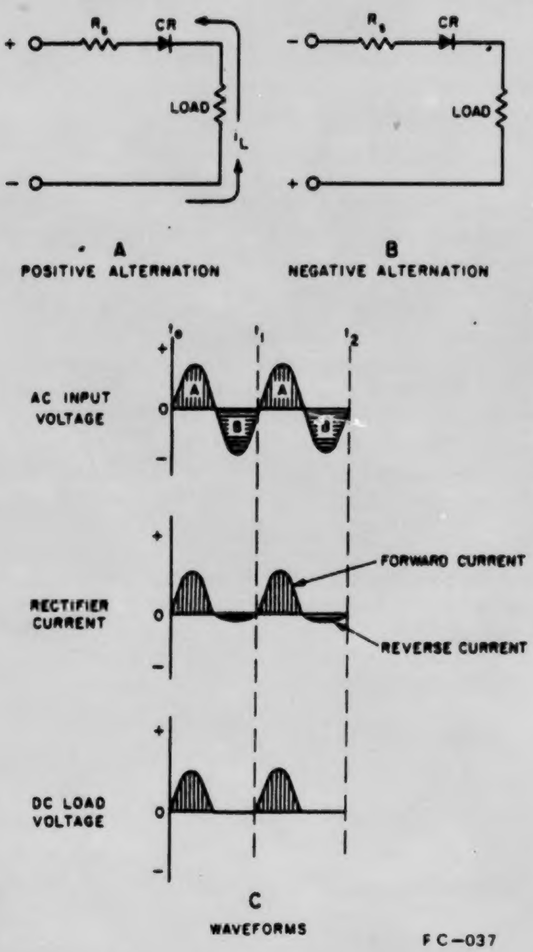

Figure 6-14. Half-wave rectifier circuit.

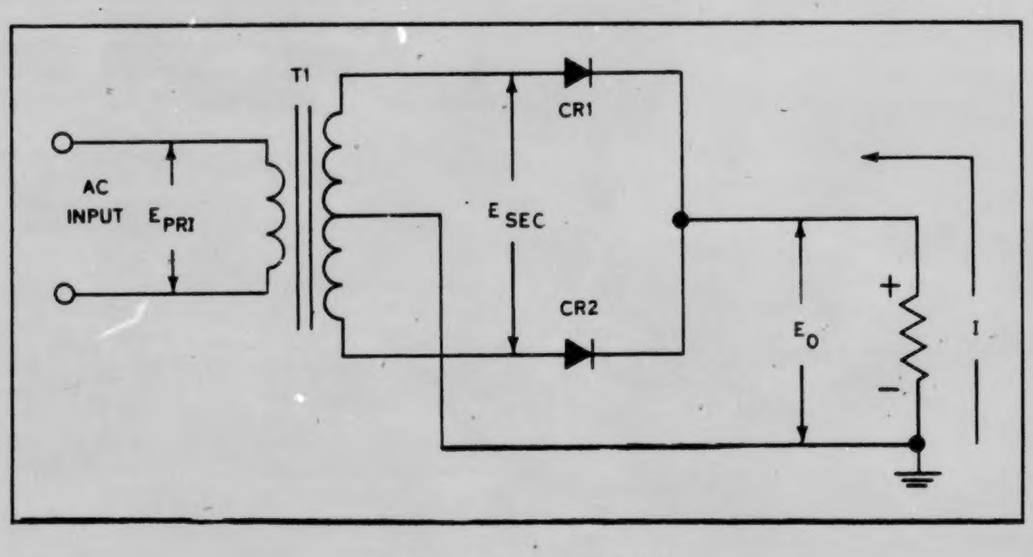

Figure 6-15. Full-wave rectifier circuit.

each complete cycle of the impressed voltage. Thus, the electron flow through the load occurs in pulses, one pulse for every other half cycle of the impressed voltage.

The operation of the half-wave rectifier circuit can be understood from the simplified circuits shown in parts A and B of figure 6-14 and the waveforms shown in part C of the figure. Assume that the AC voltage applied to the input terminals during the initial half cycle has the polarity indicated in A. Electrons flow in the direction indicated by the small arrows; their path is from the negative terminal, through the load, through rectifier CR, and to the positive terminal. Thus, during the initial half cycle, diode CR passes maximum current in the forward direction, and develops a corresponding output-voltage pulse, as shown in part C of the figure.

During the next half cycle, the polarity of the applied AC is shown in part B of the figure. Except for possibly a very small value of reverse current, the diode does not conduct because it is reverse biased. The small current that flows can be ignored because the reverse resistance of the diode is extremely high when compared with the load resistance. Thus, during the second half cycle, very little voltage is developed across the comparatively low load resistance. The waveforms shown in part C indicate that, on positive half cycles of the applied voltage, current passes through the diode and the load resistance, producing an output voltage across the load resistance. The output voltage has a pulsating waveform or ripple; the frequency of the ripple voltage is the same as the frequency of the AC source. Since the output voltage and current are not continuous, the half-wave rectifier circuit requires considerable filtering to smooth out the ripple.

Full-wave rectifiers. The single-phase, full-wave rectifier is one of the most common rectifier circuits used in electronic equipment. It is used as a low-voltage DC supply for the operation of relays, motors, telephone and teletype circuits, and semiconductor circuits. A full-wave rectifier circuit is shown in figure 6-15. It consists of a transformer with a center-tapped secondary winding. A semiconductor diode is connected to each end of the transformer secondary. The load (represented by a resistor on fig. 6-15) is connected between the center tap of the secondary winding and the common junction of the two semiconductor diodes. As a result, electrons flow through one half of the secondary winding, the load and a diode on each half cycle of the applied voltage, with first one diode conducting and then the other. Thus, the electrons flow through the load in the same direction for each half cycle of the input voltage.

Each half of the secondary winding is electrically equal to the other; the current passes first in one direction through one half of the secondary winding and then in the other direction through the other half of the secondary winding. The full-wave rectifier circuit is more efficient, has less output ripple amplitude, and twice the ripple frequency of the half-wave rectifier circuit.

The output of the full-wave rectifier circuit is normally connected to a suitable filter circuit to smooth the pulsating direct current for use in the load circuit.

Exercises (060):

1. Name the majority carrier in
   a. N-type of semiconductor material.

30 b. P-type of semiconductor material.

2. What is the result of applying forward bias to a PN junction?

3. What polarity of voltage is needed at each contact of a PN junction to cause forward bias?

4. Describe the output voltage waveform of a half-wave rectifier circuit.

5. Compare the ripple frequency of the output of a half-wave rectifier with the frequency of the applied voltage.

6. When one diode in a full-wave rectifier is conducting, what is the bias on the other diode?

7. Compare the waveform of the output voltage of a full-wave rectifier circuit with that of a half-wave rectifier circuit.

6-7. Operating Principles of Transistor Amplifiers

Because the transistor is rapidly replacing the vacuum tube, it is playing a big part in the design of all types of electronic equipment. The transistor is a device that is capable of controlling the flow of electrons. Transistors are made from materials that are classified as semiconductors. In general, all materials can be placed in one of three categories—conductors, semiconductors, and insulators. The following discussions will be concerned only with semiconductors (transistors).

061. Identify construction features and biasing arrangements of transistors.

Fundamental Theory of Transistors. We have discussed two element semiconductor diodes that permit more current to flow in one direction than the other; they have the ability to rectify. The next semiconductor that we will consider has three elements, and it can amplify.

Semiconductors that have three or more electrodes are called transistors. The three elements of the two-junction transistor are: (1) the EMITTER, which gives off or "emits" current carriers (electrons or holes); (2) the BASE, which controls the flow of the current carriers; and (3) the COLLECTOR, which collects the current carriers.

Transistors are classed as PNP or NPN according to the arrangement of the N and P materials. Transistors have two PN junctions. One is between the emitter and the base; the other is between the collector and the base.

PNP Transistor. It takes three sections of germanium to form two PN junctions. The combination of two sections of P-type germanium with a thin layer of N-type germanium is referred to as a PNP transistor. Two depletion regions (barriers) occur at the junctions when three sections of germanium are combined even though no external voltage has been applied. This phenomenon is the same as that which occurs when two sections of germanium are combined in a PN junction.

In a junction transistor, the main current is from the emitter to the collector through the base. The input signal is applied to the base of a transistor.

In using a transistor, we apply forward bias to one junction and reverse bias to the other. The emitter-base junction is normally biased in the forward (low-resistance) direction; the base-collector junction is normally biased in the reverse (high-resistance) direction.

Figure 6-16, A, shows the biasing of the first junction (emitter-base) in the forward direction, and figure 6-16, B, shows the second junction (base-collector) biased in the reverse direction. Except for a few minority carriers, there will be no current across the junction that is biased in the reverse direction. In figure 6-17 with both junctions biased, many of the holes from the emitter that enter the base do not combine with the electrons that enter the base from the emitter-base battery. Instead, they pass through the base and enter the base-collector depletion region. When these holes enter the collector, they combine with electrons entering the collector from the base-collector battery.

In the actual operation of transistors, approximately 95 percent of the current from the emitter reaches the collector.

NPN Transistor. An NPN transistor consists of two sections of N-type material separated by a thin section of P-type material. Figure 6-18 illustrates the typical NPN transistor and shows the bias connections. The theory of operation of the NPN transistor is similar to that of the PNP except that the emitter of the NPN furnishes electron charges rather than hole charges. Figure 6-19 shows the schematic symbols used for PNP and NPN transistors. Note that the emitter is always identified with an arrow. The arrow always points which way the positive hole charges will move. In the PNP transistor, the emitter

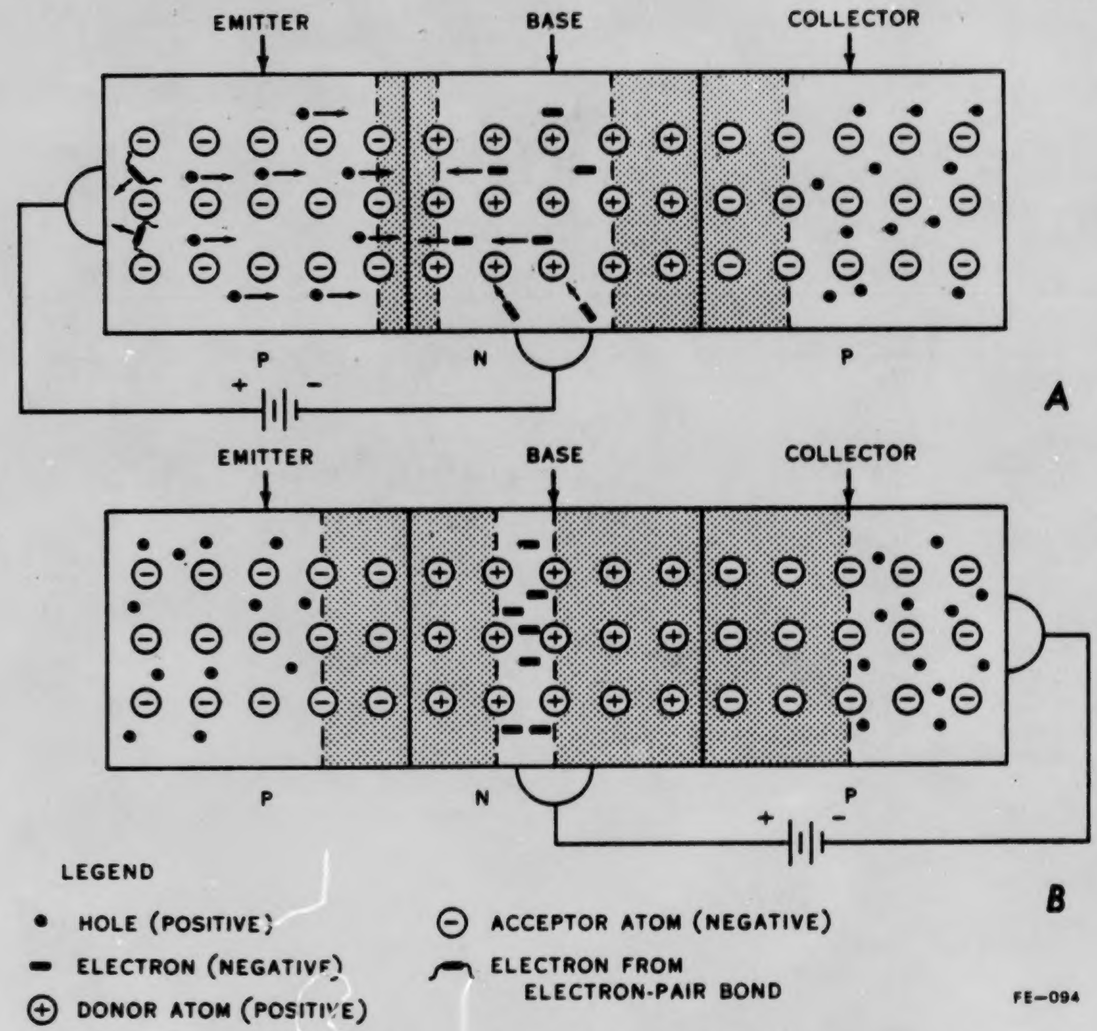

Figure 6-16. Biasing of junctions.

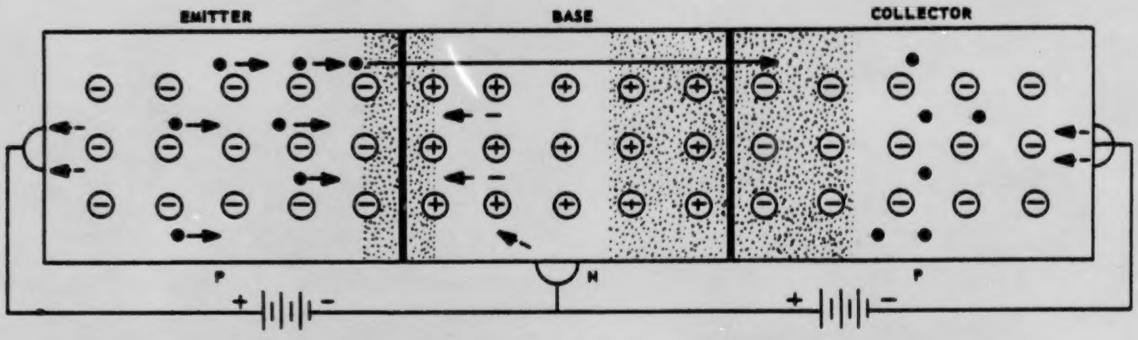

Figure 6-17. Biasing PNP transistor.

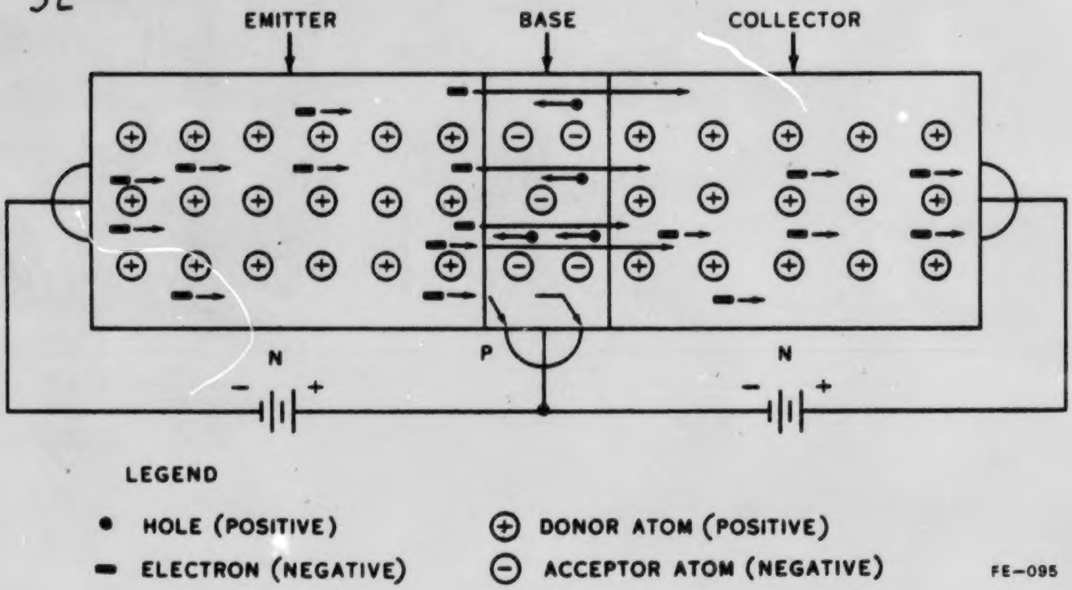

Figure 6-18. Biasing NPN transistor.

supplies hole charges to its junction; therefore, the arrow points toward the base.

In the NPN transistor, the emitter supplies electron charges to its junction; therefore, the arrow points away from the base.

When in doubt as to what kind of transistor is shown, remember that the arrow always points toward the N-type material.

Exercises (061):

1. List the electrodes of a two-junction transistor and give the purpose of each element.

2. In a two-junction transistor, which junction is normally forward biased?

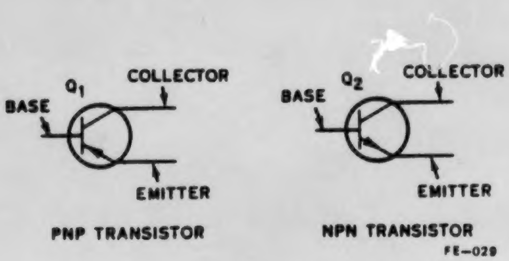

Figure 6-19. Transistor symbols.

3. In a transistor schematic, how is the emitter identified?

4. In any transistor amplifier, which element is always associated with the input signal?

5. In a junction transistor, where does the main current occur?

062. Given schematic diagrams of basic transistor amplifiers, identify circuit components and configurations.

Transistor Circuit Arrangements. There are several amplifier circuit arrangements possible for the transistor. Figure 6-20, A, shows an amplifier where the signal is introduced into the emitter-base circuit and taken from the collector-base circuit. Since the base element of the PNP transistor is common to both the input circuit and the output circuit, this arrangement is referred to as a common-base (CB) amplifier. The common-base circuit may also be referred to as the grounded-base amplifier.

In the amplifier of figure 6-20, B, the signal is introduced into the base-emitter circuit and taken from the collector-emitter circuit. Here the emitter element of the PNP transistor is common to both the input circuit and the output circuit, giving rise to the name common-emitter (CE) or grounded-emitter amplifier. A common-emitter amplifier using an NPN transistor is similar to the circuit of figure 6-20, B, but the polarities of the biasing batteries are reversed in order to maintain forward bias in the base-emitter circuit and reverse bias in the collector-base circuit.

Figure 6-20, C, shows the third possible basic circuit. Because the collector element of the transistor is common to the input and output circuits, the circuit is called a common-collector (CC) amplifier or grounded-collector amplifier. The signal is fed into the base-collector circuit and removed from the emitter-collector circuit.

Regardless of the type of circuit, the proper bias for the Class A transistor amplifier consists of forward bias on the emitter-base circuit and reverse bias on the collector-base circuit. You have seen in figure 6-20 one method of biasing each circuit configuration, but other biasing methods can be used.

Common-base amplifier. In order to operate the common-base amplifier with a single battery (see fig. 6-21), a voltage-divider network is required. The collector-base bias is achieved directly by the battery in the collector-base circuit. Since the transistor shown is a PNP transistor, reverse bias is achieved by making the collector negative with respect to the base, as shown. Forward bias in the emitter-base circuit (PNP transistor) requires that the emitter be positive with respect to the base. This condition is achieved by the voltage divider network, consisting of resistors R_3 and R_4. The current (I) from the battery causes a voltage drop across resistor R_3 with polarity as indicated. This voltage drop places the emitter at a positive potential with respect to the base. If an NPN transistor were used, only the battery would have to be reversed.

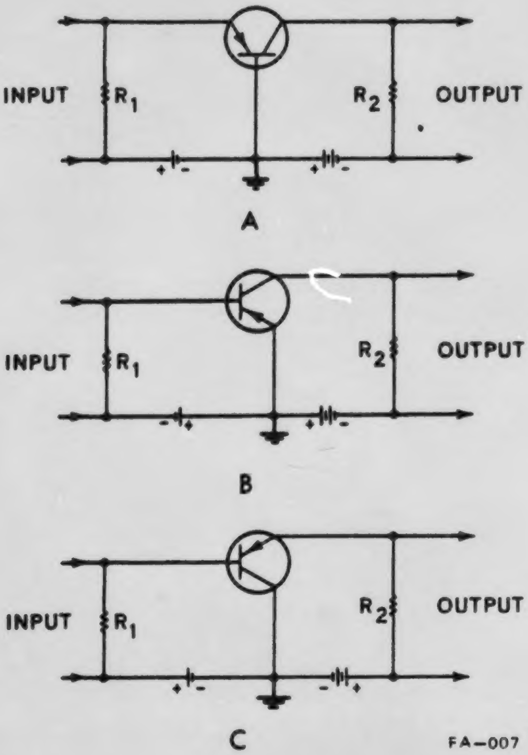

Figure 6-20. Basic amplifier configurations.

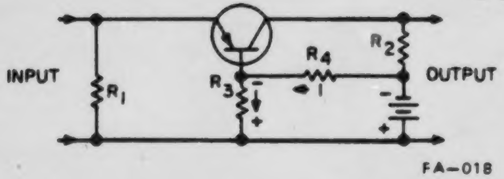

Figure 6-21. CB amplifier with one bias battery.

Common-emitter amplifier. There are two methods of introducing bias voltage from separate batteries into the common-emitter amplifier. The first method (C, figure 6-20) is used if the emitter should be placed at AC and DC ground potential in a piece of equipment. The second method (A, fig. 6-22) is used if it is desired to have the base-emitter bias battery series aid the collector-emitter. If an NPN transistor were used, both battery connections would have to be reversed.

The common-emitter amplifier may also be biased with a single battery (B, fig. 6-22). The single battery directly produces the required reverse bias voltage in the collector-base circuit. To understand the method by which forward bias between the emitter and the

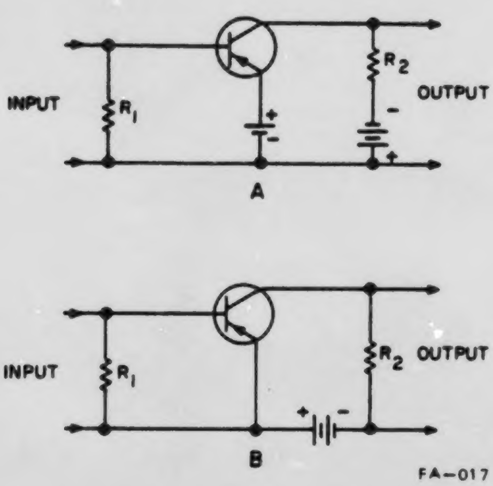

Figure 6-22. Bias methods for CE amplifier.

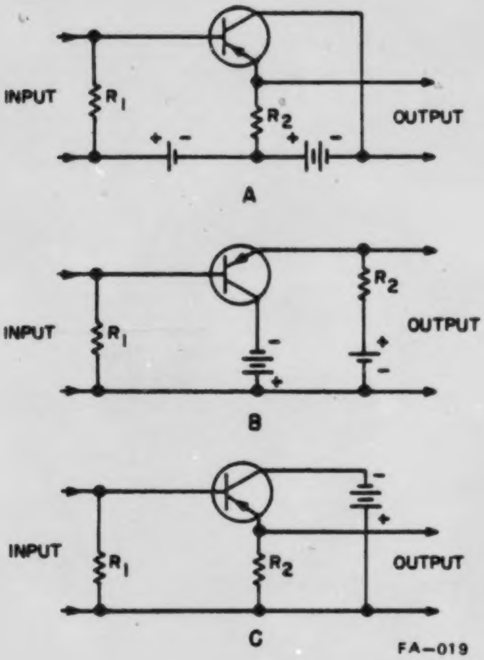

Figure 6-23. Bias methods for CC amplifier.

base is produced by a single battery, you need a knowledge of the internal structure of the transistor. We said before that forward bias for the PNP transistor requires the base to be negative with respect to the emitter. In a PNP transistor, the collector is at the highest negative potential; the emitter is at the highest positive potential. Structurally, the base is between the two; therefore, we must assume a voltage between the two. Thus, the base must be less positive than the emitter or, in other words, negative with respect to the emitter. This condition produces a forward bias. The magnitude of the voltage between the emitter and the base must be very small compared to that between the collector and the base. Internally, the two PN junctions act as a voltage divider. The PN junction between the collector and the base represents a high resistance and develops the larger voltage drop. The PN junction between emitter and base represents a low resistance and develops a low voltage.

Common-collector amplifier. There are three methods of introducing bias voltages from separate batteries into the common-collector amplifier. One method is shown in C, figure 6-20; the second and third methods are shown in A and B, figure 6-23. In each case, the batteries establish the proper forward bias (base-emitter) and the reverse bias (base-collector). If an NPN transistor were substituted, the polarities of both batteries in each circuit would have to be reversed. The common-collector amplifier can also be biased with a single battery (C, fig. 6-23). The reverse bias (base-collector) is established directly by the battery. The forward bias (base-emitter) depends on the internal structure of the transistor. The internal mechanism for establishing the forward bias is the same as that covered in the common-emitter amplifier.

Exercises (062):

1. Identify the configuration of each transistor amplifier shown in figure 6-20.

2. In figure 6-21, emitter-base bias is produced by current through what component?

3. In figure 6-22, emitter-base bias is produced by current through what component?

063. Match operational characteristics with three types of transistor amplifier circuits.

Common-Base Amplifier. Electron current through an NPN CB amplifier is indicated by the direction of the arrows in figure 6-24. To simplify the circuit explanation, the flow of the minority carriers across the reverse-biased base-collector junction has been ignored. Earlier, you learned that most of the

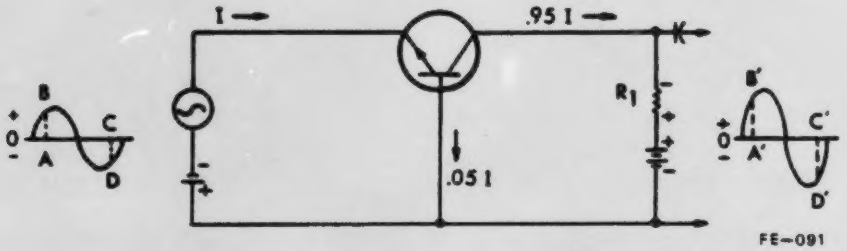

Figure 6-24. Operation of CB amplifier.

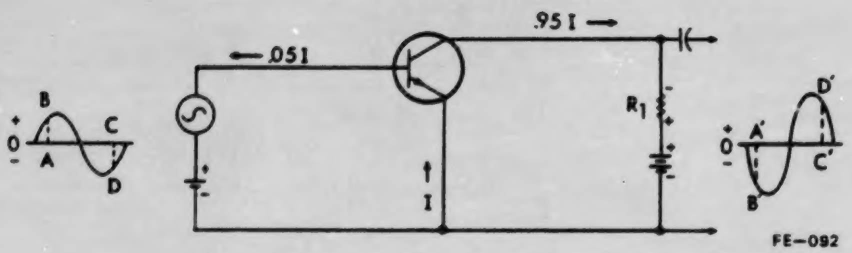

Figure 6-25. Operation of CE amplifier.

current from the emitter flows toward the collector. In figure 6-24, the total emitter current is represented by the letter I. For discussion purposes, it is assumed that 95 percent (or .95I) of the current reaches the collector; 5 percent (or .05I) flows to the base.

The waveforms on figure 6-24 represent voltage waveforms. The input signal produced by the signal generator is on the left and the output signal developed across resistor R_1 is on the right. Consider an instant of time when the voltage AB from the signal generator opposes the forward bias produced by the base-emitter battery. The resultant forward bias at this instant has been reduced, thereby reducing the total current (I) through the emitter. By corresponding amounts, the collector and the base currents have been reduced. The reduced current through resistor R_1 causes the top point of the resistor to become less negative (or more positive) with respect to the lower point. This effect is shown by A'B' on the output waveform. For the entire half cycle that the input signal is positive, it opposes the forward bias, and the output signal goes positive.

Consider a second instant of time when the voltage CD from the input signal aids the forward bias produced by the base-emitter battery. The resultant forward bias at this instant has been increased, thereby increasing the total current (I) through the emitter. By corresponding amounts, the collector and the base currents have been increased. The increased current through resistor R_1 causes the top point of the resistor to become more negative (less positive) with respect to the lower point. This effect is shown by C'D' on the output waveform. For the entire half cycle that the input signal goes negative and aids the forward bias, the output signal goes negative. From the above discussion, it can be concluded that there is no voltage phase reversal between the input and the output signal of a CB amplifier. Common-base amplifier circuits are usually designed for large voltage gain. The input resistance is low and the output resistance is high.

Common-Emitter Amplifier. The current through an NPN CE amplifier is indicated by the direction of the arrows in figure 6-25. To simplify the circuit explanation, the flow of the minority carriers across the reverse-biased base-collector junction has been ignored. The portions of emitter current through the collector and the base were discussed in the section covering the current and voltage phase relations of a CB amplifier. If a PNP transistor were used, the polarities of the batteries would have to be reversed, but the phase relationship would be the same.

Consider an instant of time when the input voltage AB from the signal generator aids the forward bias produced by the base-emitter battery. The resultant forward voltage at this instant is increased, thereby increasing the total current (I) through the emitter. By corresponding amounts, the collector and the base currents are increased. The increased current through load resistor R_1 causes the top part of the resistor to become more negative (less positive) with respect to the lower part. This effect is shown by A'B' on the output waveform. For the entire half cycle that the input signal goes positive and aids the forward bias, the output signal goes negative.

Consider a second instant of time when the voltage CD from the signal generator opposes the forward bias produced by the emitter-base battery. The resultant forward voltage is decreased, thereby decreasing the emitter current. By corresponding amounts, the collector and the base currents are decreased. The decreased current through load resistor R_1 causes the top point of the resistor to become less negative (or more positive) with respect to the lower point. This effect is shown by C'D' on the output waveform. For the entire half cycle that the input signal goes negative and opposes the forward bias, the output signal goes positive. Therefore, it can be concluded that the input signal voltage is reversed 180° in phase in going through the CE amplifier. A common emitter configuration develops a voltage gain. The input resistance is lower than the output resistance.

Common-Collector Amplifier. The electron current through an NPN CC amplifier is indicated by the direction of the arrows in figure 6-26. To simplify the circuit explanation, the flow of minority carriers across the reverse-biased collector-base junction has been ignored. The portions of emitter current through the collector and the base were discussed in the section covering the current and voltage phase relations of a CB amplifier. If a PNP transistor were used, the polarities of the batteries would have to be reversed, but the voltage phase relationship would be the same.

Consider an instant of time when the input voltage

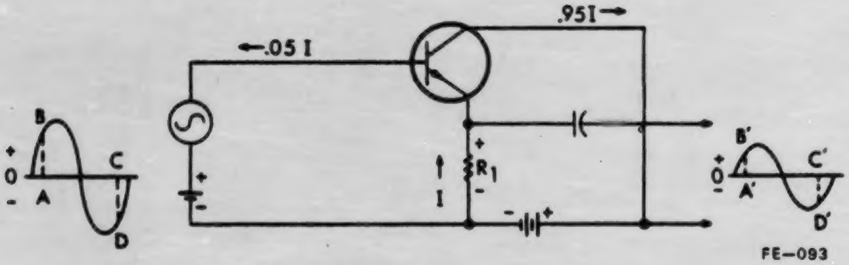

Figure 6-26. Operation of CC amplifier.

AB from the signal generator aids the forward bias voltage. The resultant forward voltage at this instant increases, thereby increasing the total emitter current (I). The increased current through load resistor R_1 causes the top point of the resistor to become more positive with respect to the lower part. This effect is shown by A′B′ on the output waveform. For the entire half cycle that the input signal is positive, the output signal is also positive.

When the input signal is negative CD, the forward bias is reduced and the emitter current is correspondingly reduced. The reduction in emitter current causes the top point of load resistor R_1 to become less positive (more negative) with respect to the lower part. This effect is shown by C′D′ on the output waveform. For the entire half cycle that the input signal is negative, the output signal is also negative. From this information, it can be concluded that there is no phase reversal between the input and output signal of a CC amplifier. A common collector configuration has a voltage gain of less than one, but the current and power gain are relatively high and the output resistance is low.

Exercises (063):

In the space by each amplifier characteristic, write in the abbreviation for the corresponding circuit. Use CB for common-base, CE for common-emitter, and CC for common-collector. More than one answer is needed for some characteristics.

____ 1. Good power gain.
____ 2. High-voltage gain.
____ 3. Voltage gain less than one.
____ 4. Low input resistance.
____ 5. Low output resistance.
____ 6. High output resistance.
____ 7. Output voltage in phase with input voltage.
____ 8. Output voltage out of phase with input voltage.

CHAPTER 7

Standard Test Equipment

IN THE MAINTENANCE business, there is a need for test equipment that may be peculiar to a given field but standard within that field. Ours is no different from the other maintenance fields in this respect. About the most common pieces of test equipment in use, regardless of the type of exchange, are the test lamp, test receiver, test telephone handset, and test board. One that is fast becoming a member of that group is the inside/outside plant automatic routiner.

In this chapter we are going to look briefly at each of the above mentioned pieces of test equipment. Our purpose is to acquaint you with each so that you may decide, when necessary, which is best to use for your given situation.

7-1. Test Lamp and Test Receiver

We start with these two because of their simplicity and similarity of use and purpose.

064. Given schematic diagrams and specified test points, state the expected test lamp and test receiver indications.

Test Lamp. The test lamp, figure 7-1, is used for testing circuit continuity. As you see in figure 7-1, its construction is very basic.

Construction. The test lamp consists of a thin metal probe connected to one side of a 48-volt bayonet-type lamp socket. To the other side of the lamp socket a length of flexible wire is connected. Connected to the end of the length of wire there is normally an alligator clip.

If we connect the clip to ground and touch the probe to 48 volts battery, the lamp will light. It also works in reverse; polarity makes no difference. It is a simple series lamp circuit.

Uses. As we said earlier, the test lamp is used for testing circuit continuity. When you think about it, most of the troubles we have in the exchange end up being an open circuit due to dirty relay contacts, an open relay or magnet winding, or a cold solder joint. We could use a multimeter, but it requires at least two hands to use and a test lamp requires only one hand. Figure 7-2 shows the test lamp being used to test the continuity of a line relay. Before you can arrive at that point however, you must check other test points. The original trouble was probably that the line relay failed to operate. Approaching this systematically, you should start by determining if battery and ground are

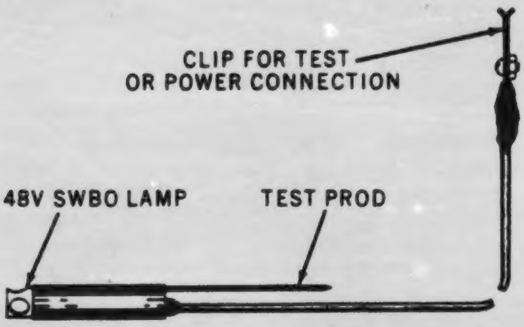

Figure 7-1. Test lamp.

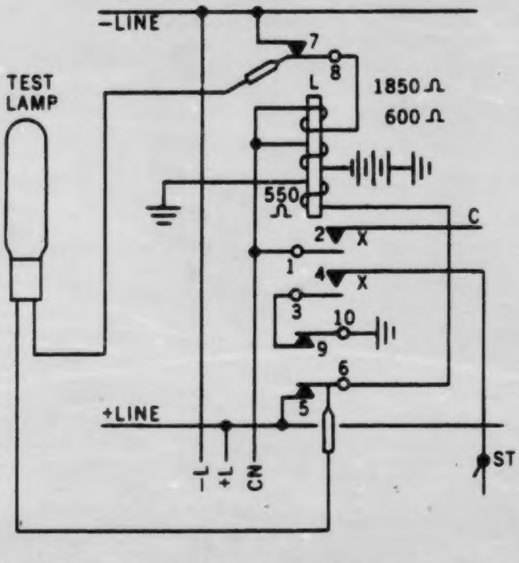

Figure 7-2. Checking continuity of relay winding with test lamp.

present. To do this, attach the clip of the test lamp to ground. Where should you touch its probe? You could go to the terminal of the relay where the battery lead is connected, but by touching (fig. 7-2) contact 8 of relay L you can kill two birds with one stone. If the test lamp lights, you not only know that battery is present, you also know that two of the relay windings are good or have continuity. Where do you go from here? Contact 7 would be your best bet. If the test lamp lights, you have proved that contacts 7 and 8 of relay L are not the source of trouble. If it doesn't light, you have found one source of trouble, possibly the only trouble. Further checking to be sure is your best move. Connecting the clip to battery and touching the probe of the test lamp to contact 6 of relay L (fig. 7-2) lights the lamp, if ground is connected to the bottom winding of relay L and that winding has continuity. As you can see, there isn't anything very difficult about using a test lamp. It is convenient and easy to use. The brightness or dimness of the lamp gives you a rough idea of the voltage present in the circuit; however, if accurate measurement is required, a multimeter must be used. The test lamp is lightweight, not bulky, and for checking circuit continuity, hard to beat. It is however, not as good for troubleshooting tone circuits as a test receiver.

Test Receiver. The test receiver (see fig. 7-3) is used for checking circuit continuity. Its use and construction are much the same as the test lamp. Let's take a look at it.

Construction. As we said, the construction of the test receiver is similar to that of the test lamp in that it is a simple series circuit from the alligator clip, through the receiver, to the test probe.

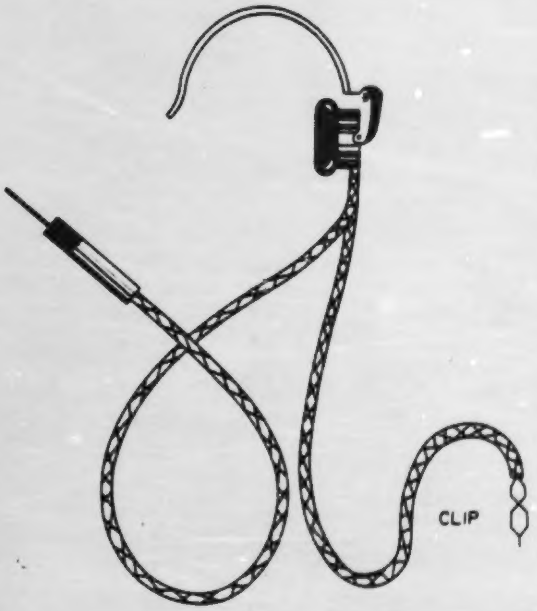

Figure 7-3. Test receiver.

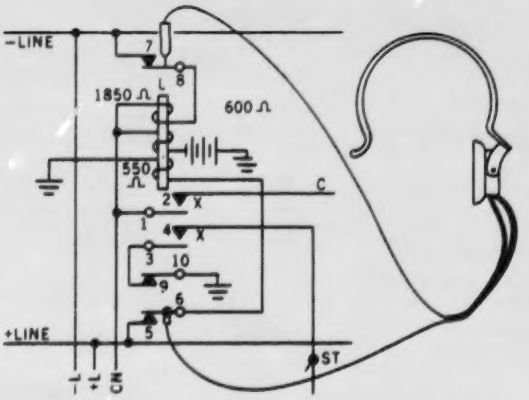

Figure 7-4. Checking continuity of relay winding with test receiver.

The test receiver has two flexible leads: one with an alligator clip connected to the end and the other with a test probe. The test probe of many test receivers has a removable series resistance built in. The resistance is there to protect your ear from extremely loud clicks. When the leads of a test receiver are placed across a 48-volt source (battery and ground), an extremely loud click is heard. Incidentally, a test receiver is commonly called a click set. Because the loudness of the click can cause ear damage, be careful when you use it.

Uses. The test receiver is used, as shown in figure 7-4, exactly the same way that a test lamp is. Before using a test receiver, it is to your advantage to place the receiver on your cheek, close to your ear, and place the probe and clip across battery and ground. This arrangement gives you the loudest click you are likely to hear and an indication of the sensitivity of the receiver.

The test receiver is particularly useful in troubleshooting tone circuits, but it may not give you as accurate an idea of the voltage and current in the circuit as a test lamp does. When troubleshooting tone circuits, you may, if your click set is so equipped, remove the series resistance in the test probe. To do this, depress the button on the probe. This removal gives the receiver a greater sensitivity, but it also makes clicks louder and more dangerous to your ears.

You can see there isn't much difference between the test receiver and the test lamp. The use of one over the other, except in limited cases, is, by and large, a matter of personal preference. Use whichever item you choose with care and safety and it will give you good service.

Exercises (064):

In the following exercises, use foldout 1 as directed.

(Foldout 1 is printed and bound in the back of this volume.)

1. If the clip of a test receiver is connected to ground, what indication is obtained by placing the test probe on contact 6T of relay H (foldout 1) when the connector is idle?

2. If a test lamp were used in problem 1 above, what would be the indication?

3. If you connect the clip of a test receiver to negative battery and teach the probe to contact 8T of relay H in foldout 1 and then to contact 11 of relay D what indications are received? Why is there a difference?

4. If the connector in foldout 1 has been seized and the clip of a test lamp is connected to ground, what indication is obtained when the test probe is placed on contact 3 of relay A?

7-2. Test Telephone Handset

The test telephone handset, often called a butt set, is another piece of test equipment that we use several times each day. All of the two-motion stepping switches and trunk circuits in your central office have jacks for it to plug into.

065. Describe the uses of the test telephone handset and its three configurations.

Construction. The test telephone handset comes packaged in two ways. Some have a metal case with two push button switches, while others come with a modern plastic case of bright color and a three-position slide switch.

Regardless of the packaging, they all do the same job. They normally come equipped with a transmitter at one end and a receiver and a dial, mounted back-to-back, at the other end. The metal encased models come equipped with two push-switches marked "R" and "C," while the plastic models have a three-position switch with a C, R, and center positions.

Uses. With the switch in the C position or the C push-switch operated (see fig. 7-5), only the receiver, in series with a capacitor, is in the circuit of the handset leads. In this configuration, if the handset is plugged into a linefinder that is in use, you are monitoring the circuit, possibly to see if it is in use or has just failed to release. With the switch in the center position or if no push-switches are operated, the transmitter and dial are in the circuit of the handset leads and in parallel with the receiver. In this configuration, if you plug the handset into an idle selector circuit, you seize the circuit. Having seized the circuit, you should use the handset dial to step the selector. You release the circuit by operating the C push-switch or unplugging the handset.

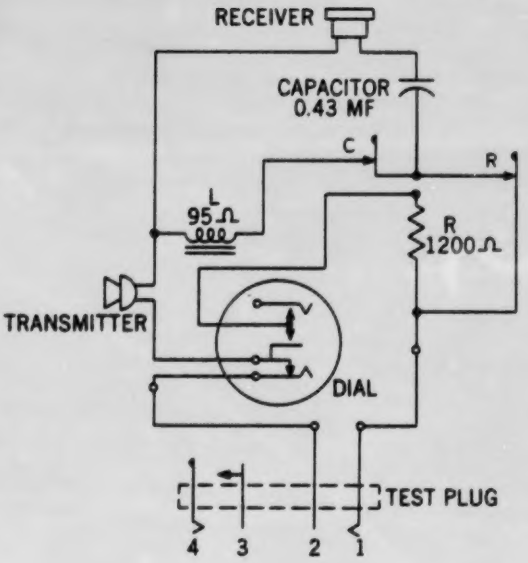

Figure 7-5. Schematic diagram of test telephone handset circuit.

You can get the other configuration by operating the R push-switch. This places 1200 ohms resistance in series with the dial and transmitter. The test handset does the same things in this configuration as it does if no push-switches are operated. The extra resistance is added to simulate extreme line loop conditions.

The test handset, as was said earlier, is probably the most commonly used piece of test equipment. Most central office personnel use it daily.

We use it when we trace calls, perform preventive maintenance inspections (PMIs), troubleshoot equipment, and even when we work on the MDF (when the plug of the handset has been replaced with alligator clips).

Exercises (065):

1. Name the three main components of a test telephone handset.

2. What, electrically, does depressing the C push-switch do to the test handset circuitry? (fig 7-5)

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3. What electrically, does depressing the R push-switch do to the test handset circuitry? (fig 7-5)

4. If the test handset is plugged into test jacks 1 and 2 of a connector (foldout 1) what happens in the connector when:

   a. The C push-switch is operated?

   b. The R push-switch is operated?

   c. No push-switches are operated?

5. When testing selectors or connectors for proper stepping, depressing the R push-switch simulates what condition?

6. When do you use the C push-switch?

7-3. Central Office Test Desk

The hub or center of testing, in most central offices,

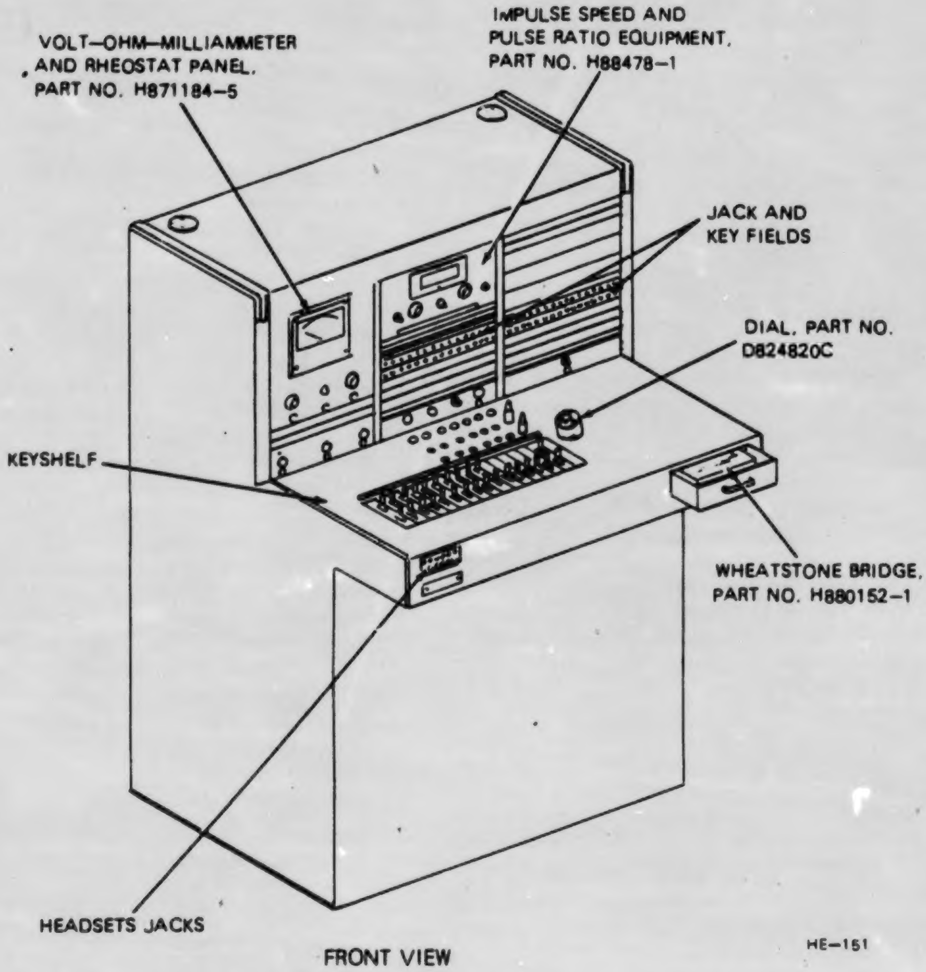

Figure 7-6. Type 1 test desk.

is the test desk. It's normally manned and busy all day long and yet it seems to be taken for granted. With the test desk, we have the capability to test both inside and outside plant; cable pairs as well as equipment. Because of its various connections and features, it allows us to do a large number of tests from one central location. Regardless of the type of exchange you work in, you've got a test desk. In a Strowger exchange, the type 1 test desk (fig. 7-6) is used in XY exchanges, types D and E are used. Each of the test desks mentioned contains face, key, and relay equipment.

066. Draw a block diagram of the type 1 test desk and specified associated circuits to show their electrical configuration and state the function of specified test desk components.

Face Equipment. The type 1 test desk face equipment includes a multimeter, dial speed and pulse ratio meter, test trunks, in-call and out-call circuits and a night alarm. Let's start with the multimeter.

Multimeter. The volt-ohm-milliammeter (fig. 7-7) is located on the left panel of the test desk. Lever switches on the test desk shelf are operated to provide ranges of 0 to 150 and 0 to 600 milliamperes; 0 to 150 and 0 to 600 volts. Three ohmmeter ranges are also provided. The low range is 1 to 5000 ohm with 500 ohms at center scale. For the intermediate range the scale reading is multiplied by 10, with 5000 ohms at center scale. For the high range, the scale reading is multiplied by 100 with 50,000 ohms at center scale.

One rheostat switch and two control knobs are located on the volt-ohm-milliammeter panel. The switch, designated RHEO, connects an adjustable resistor in series with the meter, for use in transmission test and insulation breakdown test with the 0 to 150 or 0 to 600 milliampere range. The control knob at the right of the switch controls the adjustable resistor. The other control knob, designated VM ADJ, is the ohmmeter adjustment.

Dial speed and pulse ratio meter (fig. 7-7). It is mounted in the upper center of the test desk. The meter measures dial speed in pulses per second and percent make of the dial contacts. The measurements are made electrically and are indicated on the meter, which has two direct reading scales. These scales have a range of 0 to 15 pulses per second and 0 to 100 percent make. A lever switch on the switch shelf, designated DIAL TEST, is used to connect the dial speed test circuit to the station line to test the dial of

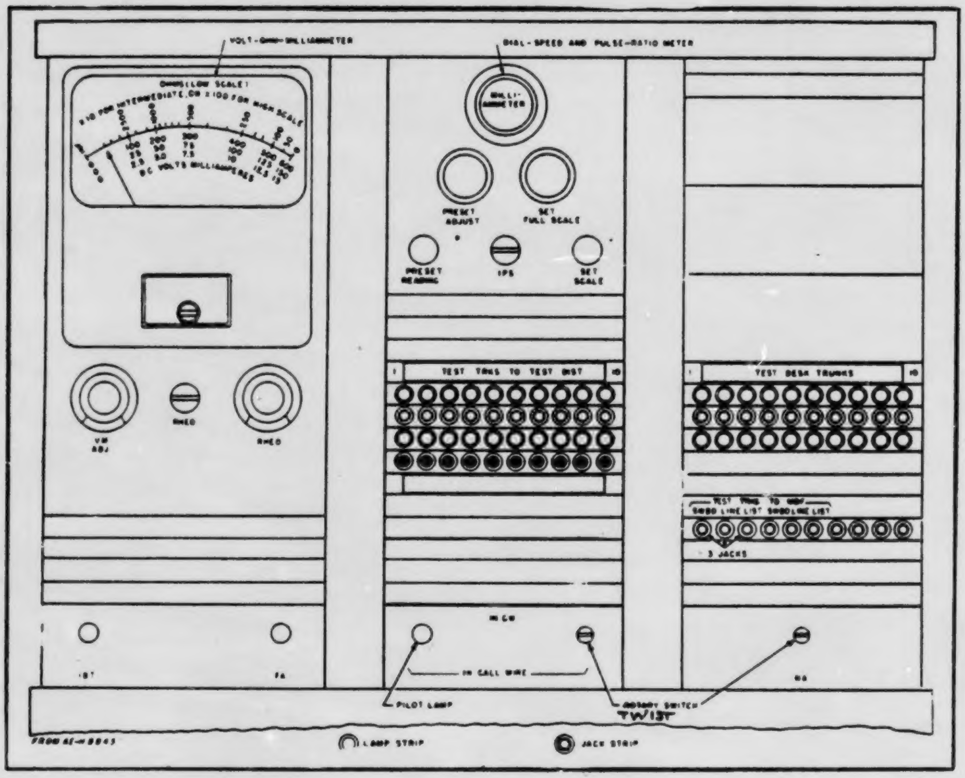

Figure 7-7. Type 1 test desk face equipment.

the station set. Relays used in the dial speed and pulse ratio circuit are located in the relay gate equipment.

One twist switch, two push switches, and two control knobs are located on the dial speed and pulse ratio panel in the center test desk panel, figure 7-7. The switch, designated IPS, is operated when dial tests are to be made. The push switch at the left is operated when making the preset adjustment by using the adjacent control knob. The push switch at the right is operated in order to set the meter to full scale by means of the adjacent control knob.

Test trunks. Jack equipment on the test desk panels provides access to trunk circuits and apparatus which permits the test man to connect to any station line.

Test trunks to distributing frame circuits consist of three jacks and associated circuit apparatus, figure 7-7. The trunk circuit connects the test cord at the distributing frame. A test shoe (fig. 7-8) permits connection to be made to any station line.

One trunk to test distributor is included in the miscellaneous switching equipment in a typical dial central office. A jack and relay rack circuit apparatus for one trunk circuit to the test distributor is usually provided on the test desk. A jack strip containing 10 jacks is installed on the panel for test distributor trunks, but normally only 1 jack is wired on the test desk. The other jacks have no application in a typical office.

A strip of 10 push switches is mounted in the center panel below the test distributor trunk jack and a lampholder strip.

These switches are operated to release the test distributor. Since normally only one test distributor is provided, the switch on the left end of the strip is the only one actually used.

Test desk trunk circuits are provided to permit access to the test desk from any dial station line. One level of the special second selector in the central office switching equipment is assigned for the test desk trunks. Ten jacks are installed on the panel, but only three trunk circuits are equipped as shown in figure 7-7.

In-call and out-call circuits. The call wire circuits are provided for communication between two or more test desks or between a test desk and an information center, a repair center, or a switchboard. The out-call wire of one desk is connected to the in-call wire of the other desk. A pilot lamp and a twist switch in the center panel of the test desk are associated with the in-call wire (fig. 7-7). The pilot-lamp lights to indicate an

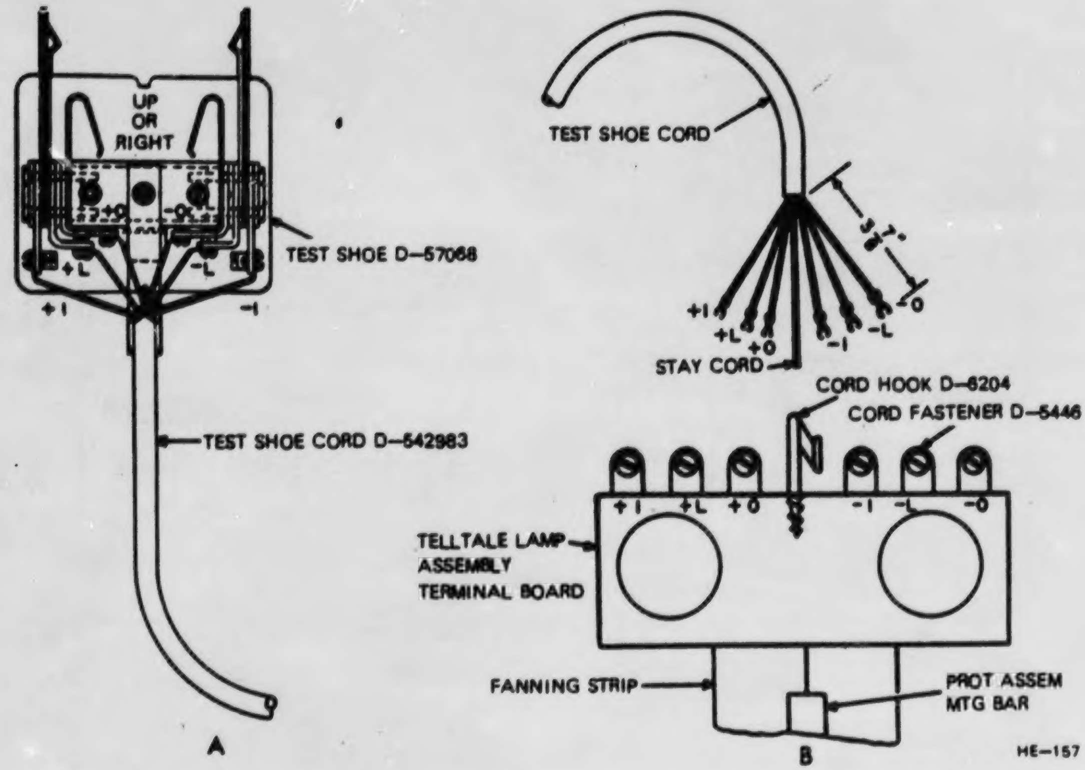

Figure 7-8. Test shoe.

incoming call; operation of the switch enables the test man to talk on the circuit without using any of the test cords or plugs. The out-call and in-call wires are not used in most offices.

Night alarm. A buzzer provides an audible signal on incoming calls for night service or for periods when the test desk is not attended continuously. The buzzer can be connected or disconnected by operating the twist switch, designated NA, on the righthand panel.

Howler and Insulation Breakdown. A howler circuit is incorporated in the test desk to signal a station by placing a varying tone on a line when the handset is not replaced. The howler is located in the central office miscellaneous switching equipment group and is cabled to the howler circuit control apparatus in the test desk.

An insulation breakdown test circuit in the test desk, using 200 volts obtained from dry-cell batteries, is associated with the howler. Two bank contact levels on the 25-point rotary stepping switch in the howler provides interrupting circuits for the insulation breakdown test.

Plug Shelf. Five test cords are located on the plug shelf, as shown in figure 7-9. The cords equipped with three conductor switchboard plugs are provided to connect the test circuits of the test desk to the test trunks. Supervisory lamps are associated with each cord except the Wheatstone bridge cord.

The primary test cord (P) is used for most of the routine testing operations which incorporates all of the tests that are made with the volt-ohm-milliammeter. When the primary test cord is plugged into a test trunk and connected to a line, operation of the test keys on the lever shelf permits the testing of resistance, current, voltage, ringing, voice transmission, and dialing.

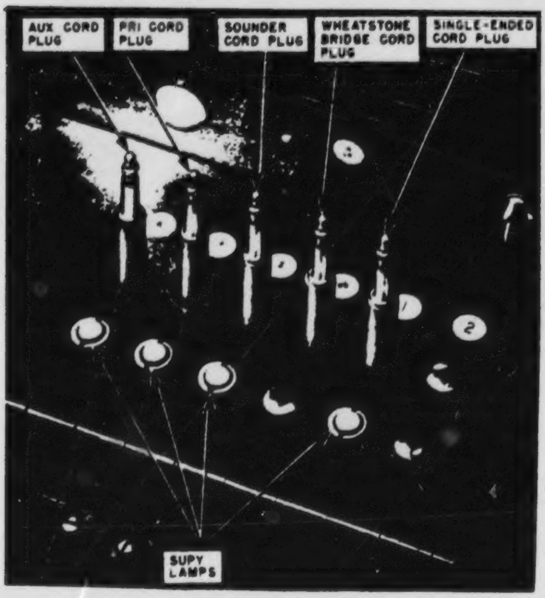

Figure 7-9. Type 1 test desk plug shelf.

The auxiliary test cord (A) is used for tests that require the connection to be held for a considerable time, thus permitting other tests to be made over the primary test cord without disturbing the previous setup. The function of the primary test cord and auxiliary test cord can be interchanged by operating a switch marked *SW* on the switch shelf.

The Wheatstone bridge cord (WB) is used for the three-wire Murray loop or Varley loop tests. When the cord is connected to the line under test, operation of proper controls on the switch shelf and the Wheatstone bridge unit permits test for faults in the outside lines. Since most test desks are not equipped with a Wheatstone bridge, this cord is not normally used.

The single-ended cord (1) is used to answer incoming calls over the test desk trunks or to dial out to station lines over the automatic switching equipment. The primary and auxiliary test cords may also be used for this purpose, but the use of the single-ended cord allows the other cords to be used for testing. The single-ended cord and the auxiliary test cord supply battery to the calling line. When you answer calls with the primary test cord, you must operate a transmission battery switch on the switch shelf to supply battery.

The sounder test cord (S) is used to put a dial tone on a line for test purposes and to give an audible sound when you are identifying pairs in a cable by short-circuiting the conductors. These functions also are performed on the auxiliary test cord, but the sounder test cord permits connection of the tone or sounder for a long period while reserving the auxiliary test cord for other tests.

Switch Shelf. Two rows of lever switches on the switch shelf control the test circuit apparatus. The lever switches, located in the front or outer row, are mainly associated with the primary test cord as shown in figure 7-10. Lever switches, associated with the auxiliary test cord and the sounder test cord are located in the rear row nearest the plug shelf. Five push switches associated with the out-call wires are located at the left of the lever switches.

Primary test cord circuit controls. With all switches in the normal or nonoperated position, the meter range (0 to 600 volts) is connected to the T & R leads of the test cord circuit. Operation of the lever switch marked "REV" reverses the connection to the T & R leads of the test cord circuit (see fig. 7-11).

The 15V-150V lever switch connects the 15-volt or 150-volt test battery in series with the meter.

The VMT-GRD (voltmeter test-ground) lever switch in the VMT position and the 15V or 150V lever switch in its correct position, permit checking the voltage of the test batteries. Operation of the VMT-GRD lever switch to the GRD position plus the operation of the 150V FEMF and the other lever switches permits testing for foreign voltage or resistance between the line and ground.

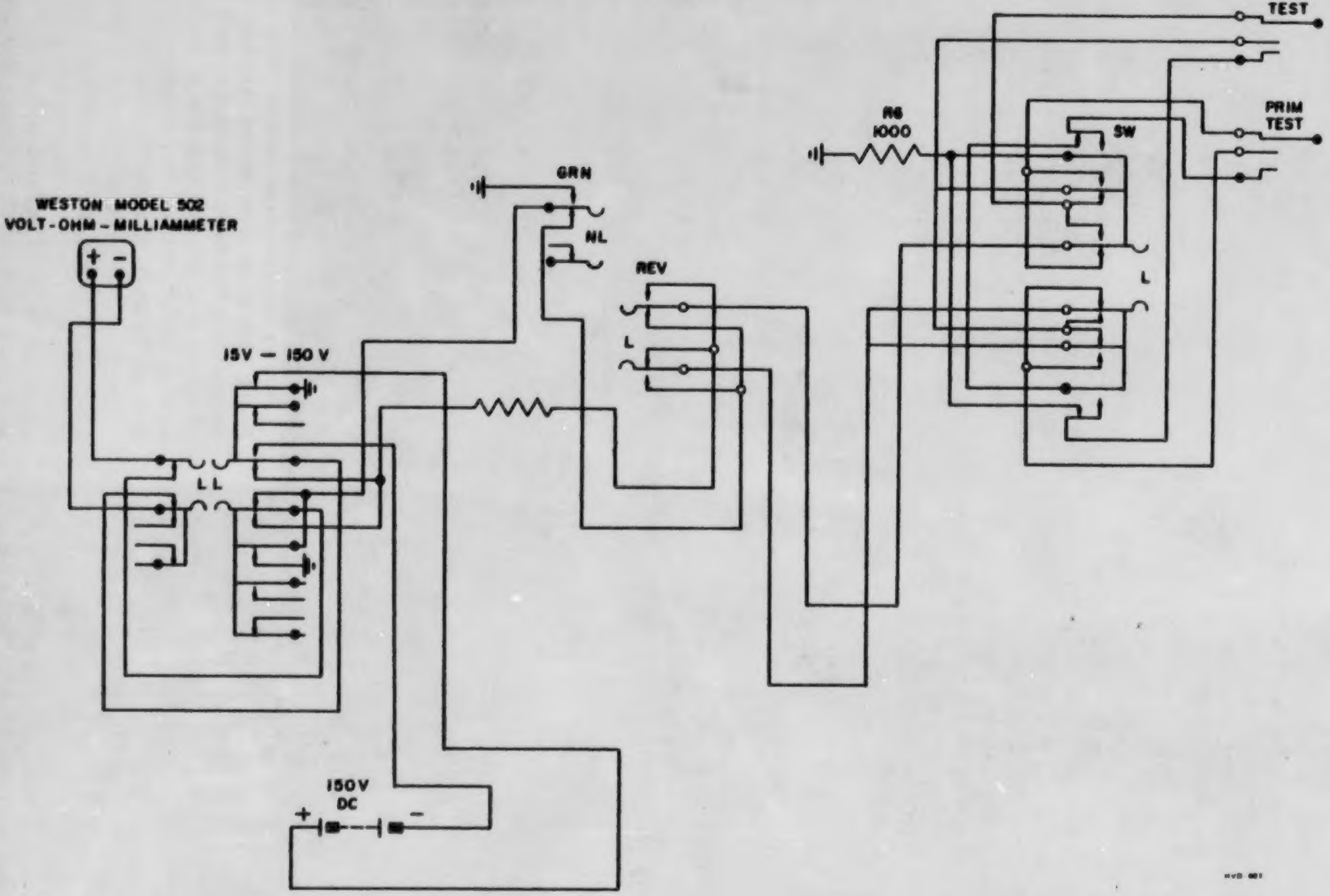

Figure 7-10. Type I test desk testing circuit, simplified.

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The T BAT-FEMF (transmission battery-foreign EMF) lever switch in the T BAT position disconnects the volt-ohm-milliammeter from the primary test cord, and connects the battery and ground to the line, permitting talking tests on the primary cord circuit.

The PRIM TALK-RING lever switch in the RING position places ringing current on the primary test cord circuit. Operation of the switch to the PRIM TALK position disconnects the volt-ohm-milliammeter from the primary test cord circuit, and connects the operator's receiver and transmitter for talking with the T BAT switch, which is also operated.

The OHM HI lever switch connects the volt-ohm-milliammeter for resistance measurements by using the highest resistance range. The range is changed to intermediate or low ranges by the additional operation of the OHM INTER-OHM LOW switch.

The TMT-CONN RLS (transmission test-conductor release) lever switch is operated to the TMT position for transmission tests. Operation of the switch to the CONN RLS position, when the test distributor trunk circuit is being used, permits the test connector to release.

The 150 MA-BCO (bridge cutoff) lever switch, when operated to the 150 MA position, connects the volt-ohm-milliammeter for reading current on the 0 to 150 in milliampere range. When this switch is operated to the BCO position, during dialing observation tests on lines over the distributor trunk, the associated line equipment is permitted to release and seize a linefinder for bridged dialing tests.

The INS BK DN TEST lever switch connects the 200-volt test battery, the insulation breakdown test circuit of the IBT, the howler switch for insulation breakdown test circuit of the IBT, and the howler switch for insulation tests on the station lines.

The WB lever switch connects the primary test cord to the Wheatstone bridge by permitting any two-wire Wheatstone bridge test to be made on the station lines.

The WB REV-GRD lever switch to the WB REV position reverses the test line connections to the Wheatstone bridge. Operation of the switch to the GRD position connects ground to the T(+) side of the line for making resistance-to-ground tests with the Wheatstone bridge.

The CT (capacitor test) lever switch connects the primary test circuit and the interrupter circuit apparatus for testing the capacitance of the station ringer capacitor bridged across the station line.

The CALL THRU-TCO lever switch to the TCO position cuts off the transmitter for monitoring on the test cord circuits. Operation of the switch to the CALL THRU position permits the test men to dial any number through the line equipment associated with the station line under test.

Auxiliary test cord circuit controls. Five lever switches in the rear row, figure 7-11, associated with the auxiliary test cord circuit, are not used in typical offices. These switches, marked RING 1, RING 2, RING 3, RING 4, and RING 5, are used only for harmonic ringing on party lines and are not used in most offices.

The RING REV-SW lever switch, figure 7-11, when operated to the SW position, interchanges the connections of the primary and auxiliary test cords so that tests may be made with the primary test circuit

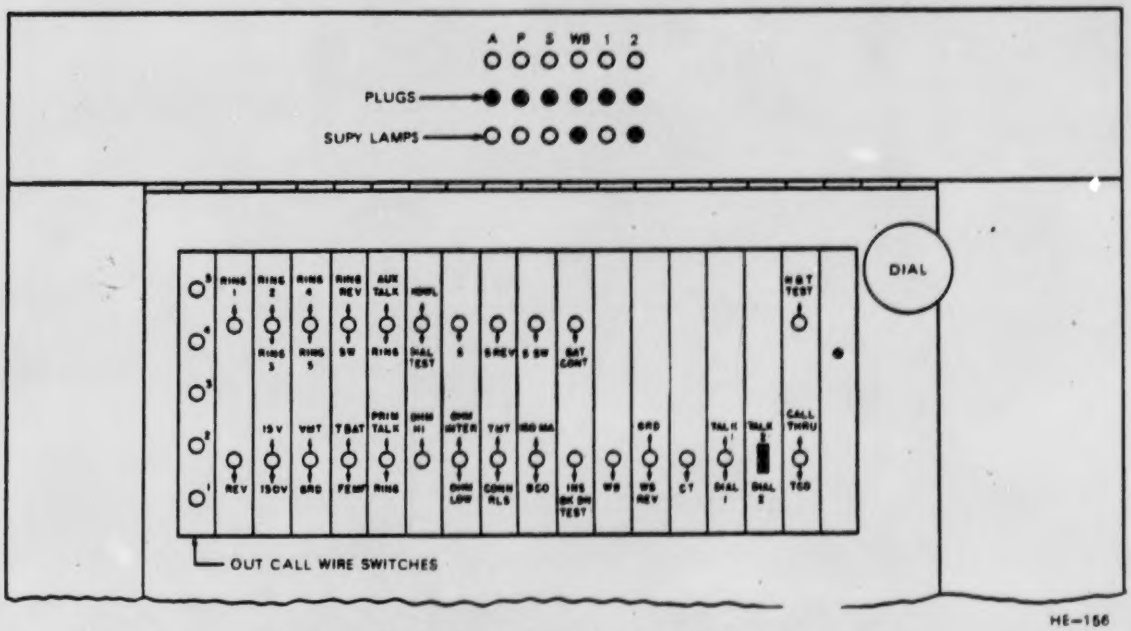

Figure 7-11. Type I test desk switch shelf.

apparatus over the auxiliary test cord, and tests with the auxiliary test circuit apparatus over the primary test cord. This makes it possible to use all of the test circuit apparatus without disconnecting the plugs from the test trunk jacks. Operation of this switch to the RING REV position reverses the ringing circuit connections for some types of divided ringing party-line service.

The AUX TALK-RING lever switch to the RING position provides manual ringing on the station lines over the auxiliary cord test circuit to the auxiliary test cord. Operation of the switch to the AUX TALK position connects the talking circuit to the auxiliary test cord.

The HOWL-DIAL TEST lever switch to the HOWL position connects the howler to the auxiliary test cord circuit for use in signaling the station lines where receivers have been left off the hooks. Operation of the switch to the DIAL TEST position connects the dial speed and pulse ratio (percent make) test circuit to the auxiliary test cord for testing the dials of the station sets.

The S, S REV, and S SW lever switches control the sounder test circuit. Operation of the S switch connects the sounder to the auxiliary test cord. Operation of the S REV switch reverses the sounder connections when used with the auxiliary test cord or

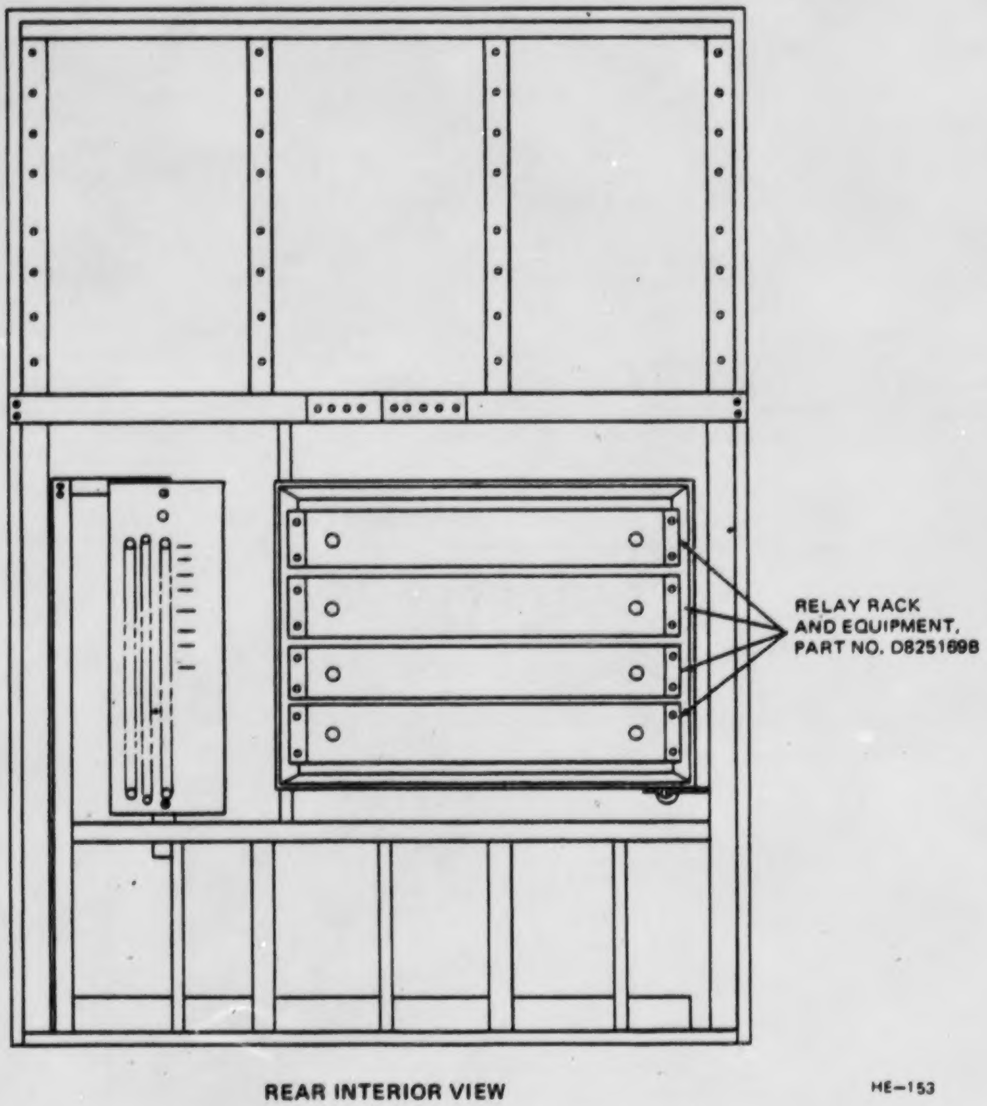

Figure 7-12. Type I test desk relay gate.

the sounder test cord. Operation of the S SW switch changes the sounder circuit to operate on removal of short circuits from the lines under test.

The BAT CONT lever switch short-circuits resistors in the battery supply leads to increase the battery voltage supplied over the station lines.

The N & TEST lever switch is used with special noise and transmission test sets which are not part of typical dial central office equipment.

Controls for single-ended cord circuit. The TALK 1-DIAL 1 lever switch is operated for talking or dialing on the single-ended cord circuit.

Relay Equipment. Relays and other circuit apparatus associated with the test desk are mounted on a hinged metal frame, called the relay gate or the relay rack, at the rear of the desk, see figure 7-12. Four metal mounting plates mount relays, capacitors, and resistors. A metal cover houses the equipment mounted on each plate. Circuit designations for the apparatus are lettered on the covers.

Exercises (066):

1. Draw block diagrams of the equipment listed below to show lever switches; jacks, plugs; etc; from the test desk to the equipment listed.
   a. Test shoe.

   b. Test connector.

   c. Dial speed through the test desk trunk.

2. State the function of each of the following listed test desk components.
   a. 15V-150V switch.

   b. PRIM TALK-RING switch.

   c. CALL THRU-TCO switch.

   d. RING REV-SW switch.

   e. OHM HI switch.

   f. 150 MA-BCO switch.

   g. CT switch.

   h. HOWL-DIAL switch.

   i. NA switch.

   j. Test cords.

   k. Relay gate.

067. Draw a block diagram of the type D test desk and specified associated circuits to show their electrical configuration and state the function of specified lever switches.

Face Equipment. The face equipment of the type D test desk (fig. 7-13) includes a multimeter, trunk switches, and test trunks. We start our discussion with the multimeter.

Multimeter. The multimeter is used to register ground, crosses, reverses and open circuits in the inside and outside telephone plant. The test desk operator uses the meter along with the keys on the keyshelf to make the following tests:

(1) Resistance.
(2) Capacitance.
(3) Foreign battery.
(4) Transmission.
(5) Pulse speed and percent make.
(6) Current measurements.
(7) AC voltage.

Trunk switches. The trunk switches enable the test desk operator to connect the primary or auxiliary tip and ring test leads to tip and ring of the line to be tested. These switches are labeled as follows:

(1) MDF IN—MDF OUT
(2) TEST SEL TRK
(3) SEL LEVEL TRK

Outside plant test equipment. Facilities are also provided to aid in clearing outside line faults. These facilities consist of the howler, sounder, and

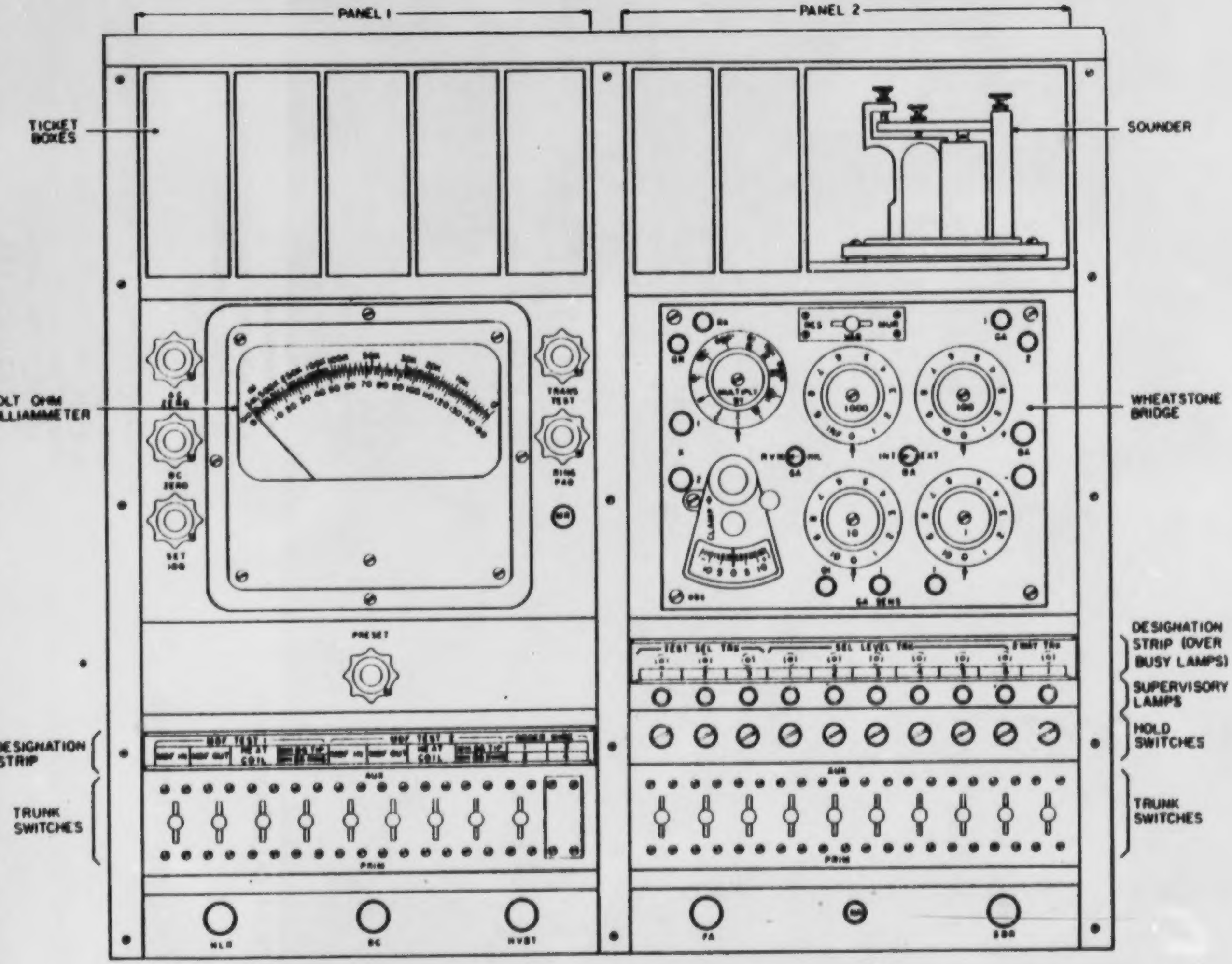

Figure 7-13. Type D test desk face equipment.

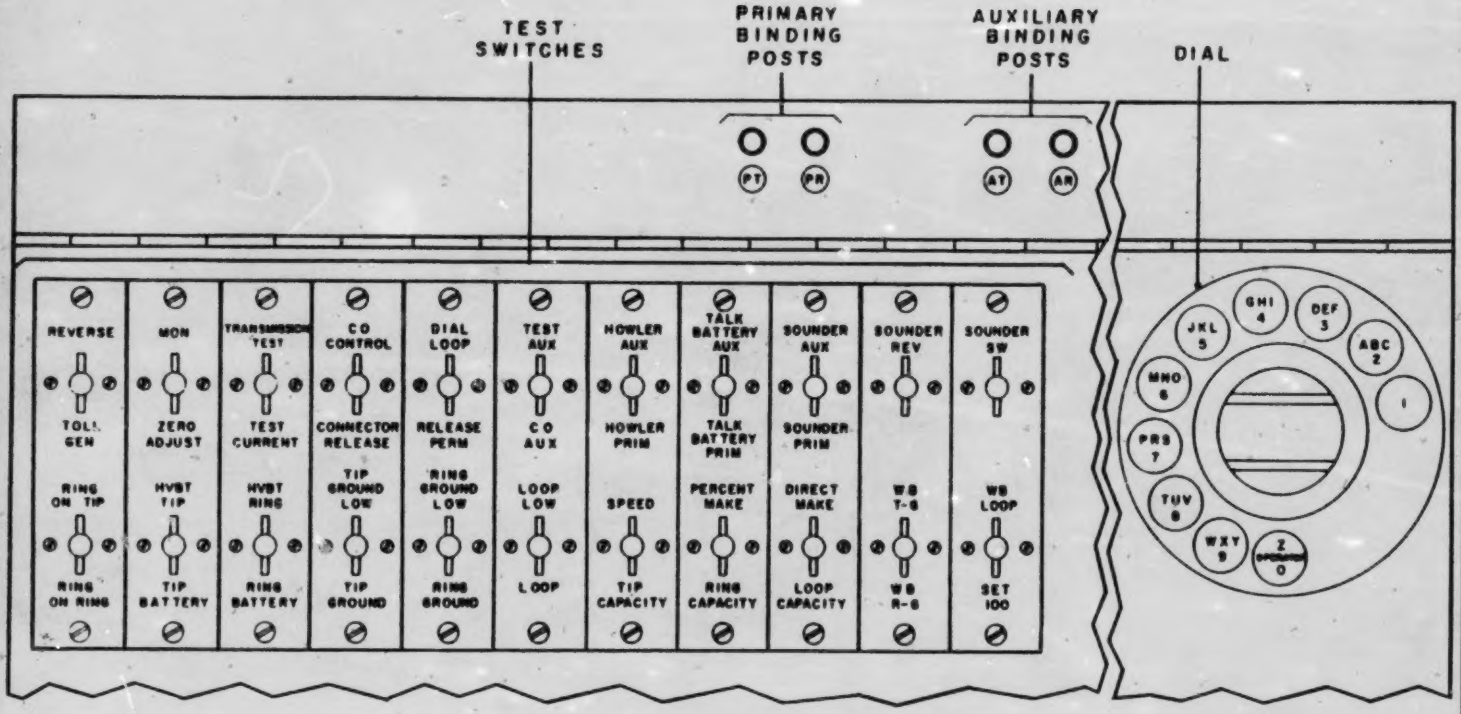

Figure 7-14. Type D test desk keyshelf equipment.

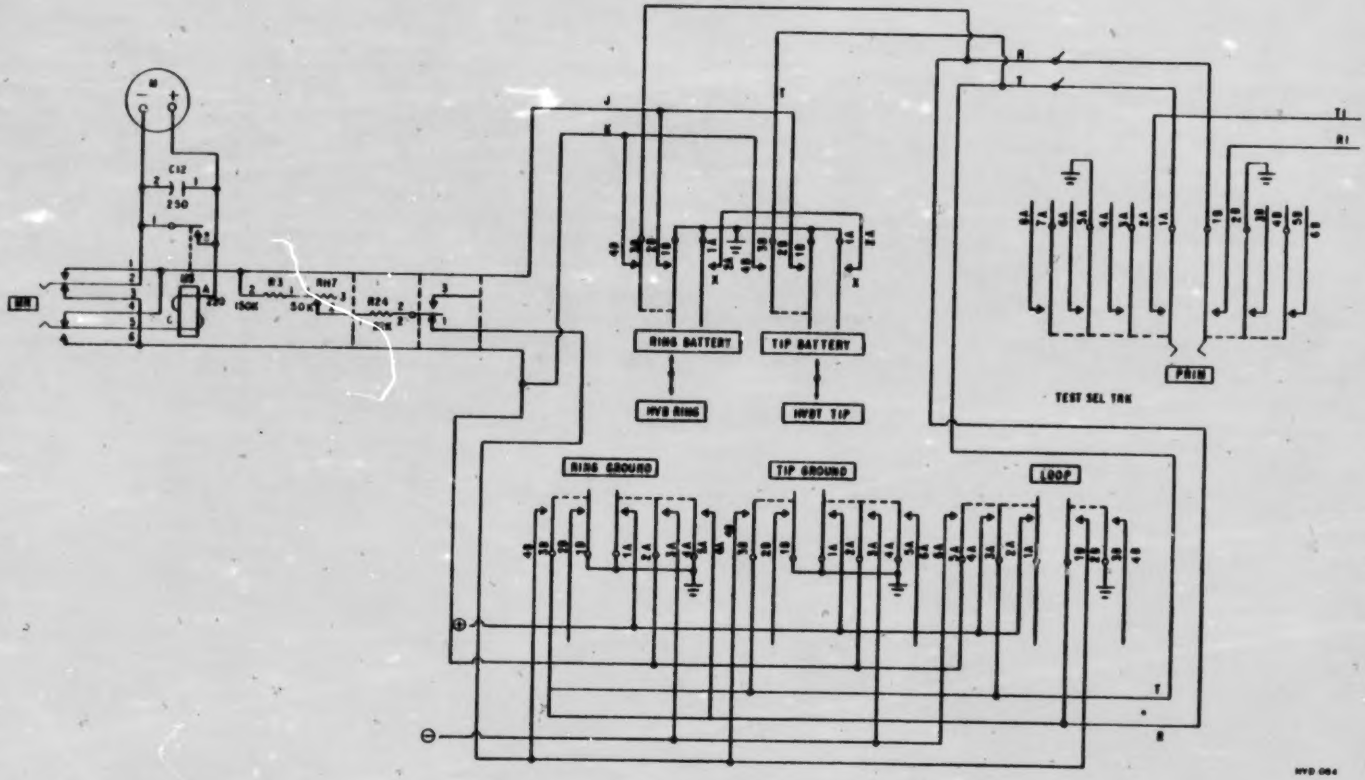

Figure 7-15. Type D test desk testing switches.

Wheatstone bridge. Tests can be made utilizing these circuits from the test desk over the following accesses:

(1) Inspector's trunk.
(2) Test switch train.
(3) Test shoe.
(4) Binding posts.

Keyshelf Equipment. The hinged section of the keyshelf, figure 7-14, contains the necessary test keys to apply the various tests, through the testing facilities previously discussed, to the lines under test. Listed below are the keys you use and their purpose (see fig. 7-15).

(1) Tip Battery—Permits testing for 0 to 150 volts of battery on tip.

(2) Ring Battery—Permits testing for 0 to 150 volts of battery on ring.

(3) Tip Ground—Permits testing for ground on the tip lead. The meter reading, if any, will be in ohms for the ground and loop test.

(4) Ring Ground—Permits testing for grounds on the ring lead.

(5) Loop—Permits measurement of resistance between tip and ring.

(6) Tip Capacity—Permits testing for capacity between the tip lead and ground.

(7) Ring Capacity—Permits testing for capacity between the ring lead and ground.

(8) Loop Capacity—Permits testing for capacity between tip and ring leads.

(9) Release Permanent—Used with the test selector trunk to release line equipment which is held operated because of a permanent condition.

(10) Howler Primary/Howler Auxiliary—Connects howler tone to primary or auxiliary tip and ring.

(11) Talk Battery Primary/Auxiliary—Connects transmission battery to the primary on auxiliary tip and ring leads.

Dial. The dial is used to access the inside equipment through the various test trunks.

Operator's Jacks. Two jacks enable easy access to the testing circuits, one on either side of the lower keyshelf.

Test Circuits. The MDF trunk is used to extend the primary or auxiliary test lead to the main testing circuit to a test shoe at the main distributing frame. The functions of the MDF trunk are listed below.

The MDF OUT switch is used to make tests on outside lines or trunks without affecting the inside dial equipment over the testing leads of the main testing circuit. The operation of the MDF OUT switch to the PRIM position extends the PT and PR leads from the main testing circuit to the test shoe. At the test shoe the testing leads are extended through the test shoe and the protector to the outside plant equipment. The test operator can now perform the required tests on the outside plant equipment.

The MDF IN switch is used to make tests on inside dial central office equipment, bypassing the heat coils of the protector over the testing leads of the main testing circuit. Operation of the MDF IN switch to the PRIM position extends the PT and PR leads from the main testing circuit to the test shoe at the protector. The testing leads are extended through the test show to the inside plant equipment. The test operator may now make the tests on the inside plant equipment.

The HEAT COIL switch is used to make tests on the inside dial central office equipment, through the heat coils of the protector over the testing leads of the main testing circuit.

Connector routine test circuit. This circuit will test the individual line connections for ringing on a bridged ringer, with a 15k-ohm leak during ringing. Ringing is tripped after the second pulse by a 1500-ohm loop. The transmission path is tested by two pulses of dial tone on the ring side, followed by one pulse of dial tone on the tip side. Answer supervision is tested by operating and releasing the AB relay. A total of three tones is heard if the transmission path is complete. If only two tones are heard it is an indication that the tip conductor is open. If one tone is heard, this indicates the ring conductor is open. No tones indicate both sides are open.

Dial speed test circuit. The dial speed test circuit is used by the telephone installer to check an installed telephone for the percent make and dial speed. The installer must dial the number 115 to seize the circuit.When the circuit is seized, the installer will receive only one spurt of dial tone. He then must dial the digit 0; any other number will be rejected. When the dial under test returns to normal, one spurt of dial tone indicates a slow dial, two spurts of dial tone indicate the dial is standard, three spurts of dial tone indicate the dial is fast. This test may be repeated as many times as desired by redialing the digit 0.

Test selector trunk. The test selector trunk provides access from the test desk to any one of the lines in the central office via the test selector and the test connector. No provision is made for incoming calls over this trunk. However, the test selector may be accessed from the attendant's cabinet to verify calls when necessary. These circuits are normally called test switch train.

Selector level trunk. The selector level trunk is used by the outside plant repairman or installer to gain access to the test desk through the central office equipment. This enables the test desk operator to accomplish the line tests required.

Exercises (067):

1. Draw block diagrams of the equipment listed below to show lever switches, etc., from the test desk to the equipment listed.
   a. Test shoe.

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b. Test connector.

c. Selector level trunk.

2. State the function of each of the following listed lever switches.
   a. MDF IN

   b. TEST SEL TRK

   c. Release Permanent

   d. Loop

   e. Tip Ground

   f. Ring Battery

   g. HEAT COIL

7-4. Inside/Outside Plant Automatic Routiners

At this point you realize that the main purpose of your Air Force life is to provide the very best telephone service possible. One way to provide good service is to test, on a routine basis, the various components that make up the telephone plant. This testing is even more important than it used to be, as subscribers expect a higher quality of telephone service these days.

As the quality of service has improved, so have the methods for testing the plant. In most of our central offices we have two types of automatic routiner. The automatic line insulation routiner checks the subscribers cable pair and telephone instrument; the automatic equipment routiner checks switch train equipment. With this equipment we are able to perform these tests more easily, more accurately, and with a manpower savings.

068. Describe the functions of specified controls of the automatic line insulation routiner.

Automatic Line Insulation Routiner. The automatic line insulation routiner runs uninterruptedly, testing for line insulation faults, below a preselected minimum sensitivity level, on all subscriber lines or on just specified number groups.

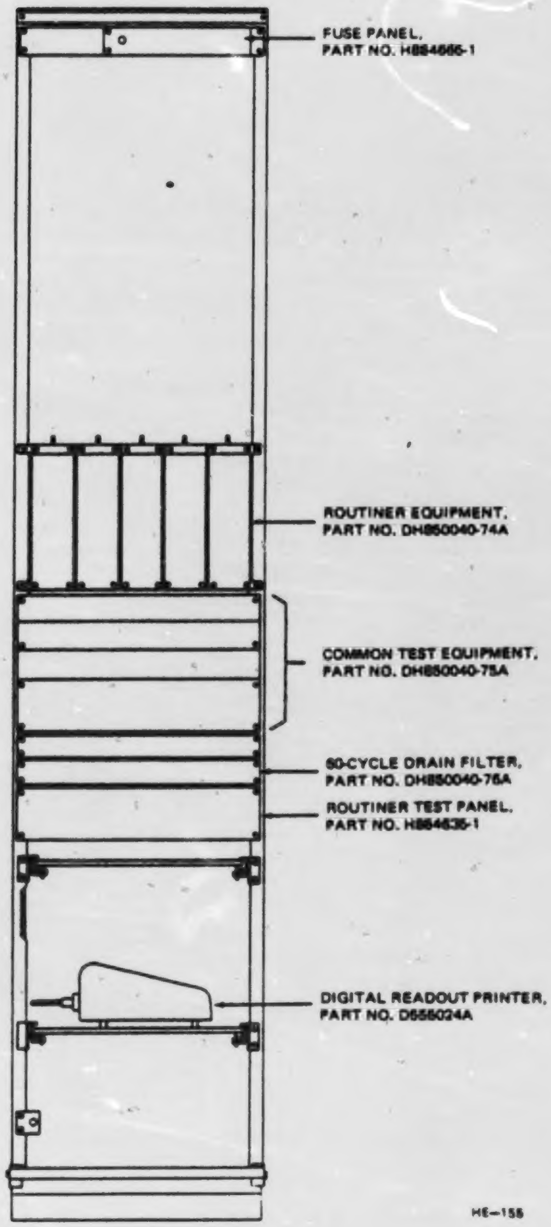
FUSE PANEL, PART NO. H884666-1
ROUTINER EQUIPMENT, PART NO. DH850040-74A
COMMON TEST EQUIPMENT, PART NO. DH850040-75A
60-CYCLE DRAIN FILTER, PART NO. DH850040-76A
ROUTINER TEST PANEL, PART NO. H884636-1
DIGITAL READOUT PRINTER, PART NO. D656024A
HE—155

Figure 7-16. Automatic line insulation routiner equipment rack.

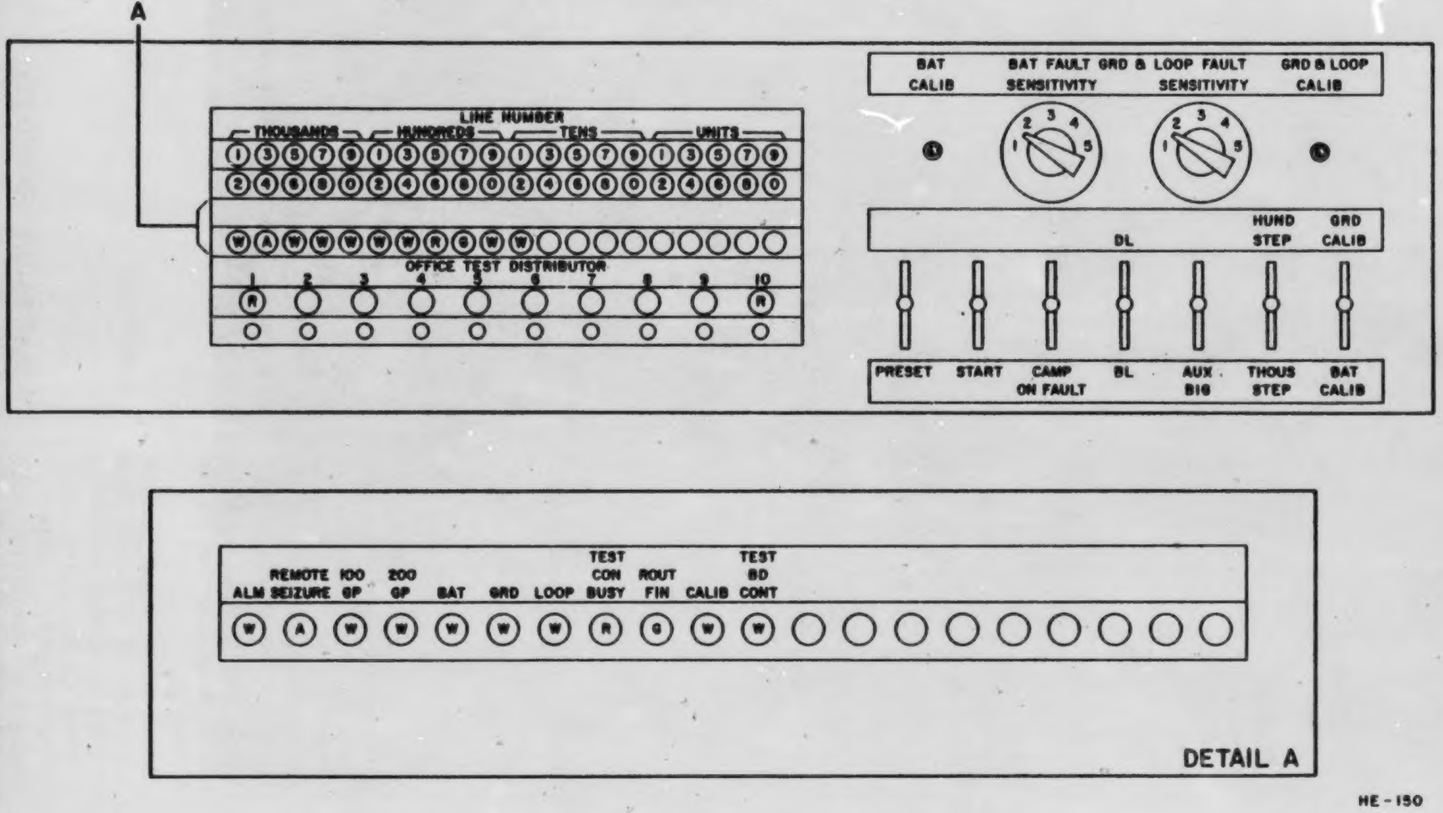

Figure 7-17. Automatic line insulation routiner test panel.

The routiner is rack mounted, as shown in figure 7-16. When the routiner locates a fault, it stops and prints out on a tape the fault location information. This information includes: (1) the sensitivity level (below which the fault was detected); (2) the telephone number in trouble; and (3) the type of fault located (loop (short), ground, battery, or a combination of faults).

The routiner is designed to operate without someone watching it. It can, however, be set to stop on a faulty line and sound an audible alarm, or run through all the lines and print out all faults encountered on a tape. It tests the lines using the test distributor trunk and test connectors.

Test Panel. The test panel, figure 7-17, contains the controls for setting up and initiating the insulation tests and the indicators, which display test status and test results. There are seven lever switches for selecting the mode of operation and two rotary switches for selecting the sensitivity level at which the lines are to be tested.

Rotary switches (fig. 7-17). The battery fault sensitivity switch sets the sensitivity range for detecting battery line insulation resistance, ranging from 50,000 ohms up to 1 megohm. The ground and loop fault sensitivity switch sets the sensitivity range for detecting the minimum acceptable loop and ground insulation resistance, ranging from 50,000 ohms to 1 megohm.

Lever switches (fig. 7-17). The PRESET switch seizes the test distributor of the office being tested. The START switch, as you may have guessed, starts the routiner; it is a nonlocking lever key. The CAMP ON FAULT switch, when operated, causes the routiner to stop when it finds a fault and to light the alarm lamp. If the AUX SIG switch (third from the right) is operated, a buzzer also sounds.

The DL-BL switch is used in conjunction with the GRD CALIB-BAT CALIB switch for calibrating the sensitivity of the fault detection circuits. Operating the switches to the DL and GRD CALIB positions permits adjustment of the GRD and LOOP CALIB screwdriver control to set the sensitivity of the ground and loop fault detection circuits. Operating the switches to the BL and BAT CALIB positions permits adjustment of the BAT CALIB screwdriver control to set the sensitivity of the battery fault detection circuit.

The THOUS STEP-HUND STEP switch is used for testing specific line number groups other than the first line number group in the office.

In the upper left-hand corner of the test panel are 40 lamps arranged in four groups of 10. The lamp jewels (covers) of each group are numbered 1 through 0. Lit lamps show which line is being tested; depending on which one in each group of lamps is lit. The row of lamps directly below the number group lamps, as seen in detail A of figure 7-17, indicates certain line conditions, for the line under test and office conditions.

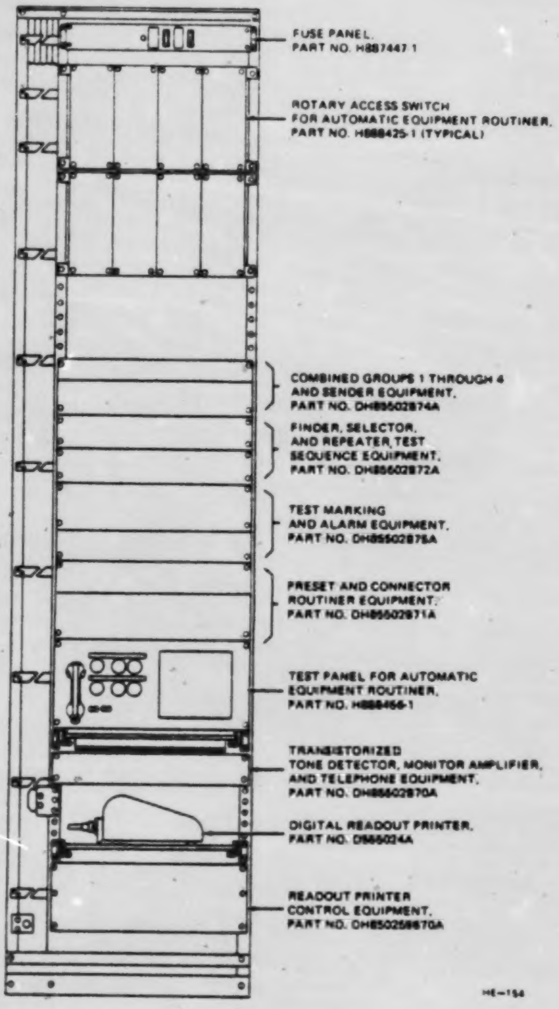

Figure 7-18. Automatic equipment routiner equipment rack.

Exercises (068):

State the functions(s) of the switches listed below.

1. PRESET

2. AUX SIG

3. BAT FAULT SENSITIVITY

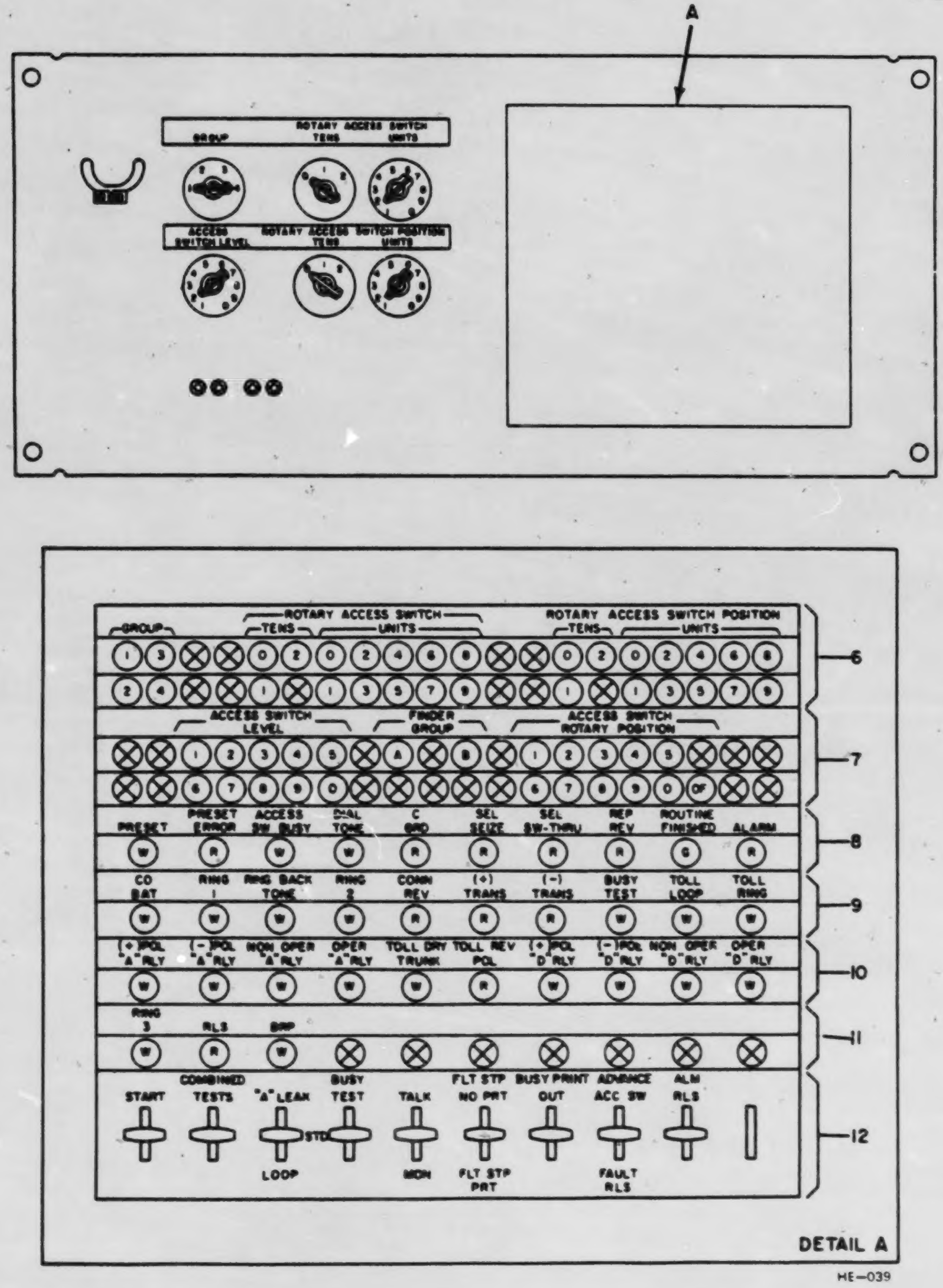

Figure 7-19. Automatic equipment routiner test panel.

GROUP			GROUP			GROUP			GROUP			GROUP			GROUP			GROUP			GROUP		
SW			SW			SW			SW			SW			SW			SW			SW		
ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY
01			01			01			01			01			01			01			01		
02			02			02			02			02			02			02			02		
03			03			03			03			03			03			03			03		
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24			24			24			24			24			24			24			24		

GROUP			GROUP			GROUP			GROUP			GROUP			GROUP			GROUP			GROUP		
SW			SW			SW			SW			SW			SW			SW			SW		
ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY	ROT SW POS LP	I S SWITCH	IN BAY
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Figure 7-20. Access switch location chart.

4. CAMP ON FAULT

5. GRD CALIB-BAT CALIB

6. THOUS STEP-HUND STEP

069. Describe the functions of specified controls of the automatic equipment routiner.

Automatic Equipment Routiner. The automatic equipment routiner is designed to test switch equipment functionally (switch trains and interoffice repeaters). The routiner, figure 7-18, is rack mounted, as is the line insulation routiner. It provides up to four test groups to permit testing of linefinder—first selector combinations, intermediate selectors, connectors, and local interoffice repeaters. It comes equipped with a printer for printing out the faults it locates.

When testing an equipment group, the routiner tests each switch in that group, stepping past busy switches and stopping only when a test requirement is not met or when routining is completed.

Test Panel. The test panel, figure 7-19, contains the controls and indicators used to set up the various tests. Maintenance personnel (you) select the desired test group, rotary access switch, the position of the rotary access switch, and the vertical level of the secondary access switch (selector switch) using the test panel.

Group, rotary access switch, access switch level, rotary access switch position? Where do I start? These are logical questions, and here are the answers.

Rotary switches. The group switch, positions 1 through 4, determines the equipment combinations being tested. When set on 1, the linefinder—first selectors are selected for testing; when set on 2, the intermediate selectors (second, special 2nd, 3rd, etc.) are selected. When set on 3, local connectors are selected, and position 4 selects local interoffice repeaters.

Before you read about the other three switches, you need to look at figure 7-20. The group switch with four positions isn't too tough to handle, but, beyond that, memory is a poor substitute for knowing where to position the other switches. Figure 7-20 shows a part of the access switch location chart which is located under a sheet of acrylic plastic on top of the routiner's writing shelf.

Starting at the top of the chart we find GROUP; the number for the specific test group appears here. Beneath this is the SW block; the number in this block indicates which rotary access switch is used for this test of a specified equipment. We now run into three columns: (1) ROT SW POS LP; (2) IS SWITCH; and (3) IN BAY.

Let's talk about the rotary access switch. It is just what its name implies; a rotary switch, similiar to that used as a distributor switch in a Strowger linefinder shelf, that accesses up to 24 switches (mostly selectors) in the central office switching equipment. The number of rotary access switches used by a routiner depends on the size of the exchange. An office of 800 lines will have fewer access switches than a 3000-line office. The Rotary Access Switch can have up to 24 trunks into the central office connected to its banks.

Now, back to our three columns. The ROT SW POS LP column indicates the bank positions on the specific rotary access switch. The IS SW column next to it tells us what switch in the central office is connected to a given rotary access switch bank contact. The next column IN BAY tells us in what equipment bay that switch (IS SW) is located.

Normally, the switch identified in the IS SW column is the first selector on a shelf of selectors or a linefinder group test number. In a Strowger central office the first selector on all selector shelves is connected to the banks of a rotary access switch. This doesn't affect the normal operation of the selector and gives the routiner access to the central office switching equipment. For testing linefinder—first selector combinations, the two test numbers, 29 and 99, are connected to the banks of the rotary access switch.

Let us assume we want to test a linefinder—first selector combination other than the first group automatically tested. We know that the GROUP switch is placed on position 1. By looking at the access switch location chart SW block we find the number of the rotary access switch to use. If switch 12 is indicated, we turn the Tens switch to 1 and the Units switch to 2.

We are almost there; we have our Group switch set for the proper test; we have selected the proper Rotary Access Switch; and all that is left to do is to set the Rotary Access Switch Position switches. If the IS SWITCH and IN BAY columns indicate 09 and 10 for the linefinder shelf we want to test, we set the Tens and Units switches at 09, as the routiner will automatically step to 10 after the routining of 09 is tested individually by the routiner and there are two groups for each linefinder shelf.

Lever switches. Look at detail A of figure 7-19. At the bottom of the panel there are seven lever switches and the top portion contains eight rows of lamps. Let's start with the lever switches.

The START switch starts the routiner; but is not necessarily the first switch operated. The next switch to the right is the COMBINED TESTS switch. As the name implies, it combines the tests. With this switch operated, test groups 1 through 4 are tested in sequence.

The "A" LEAK-STD-LOOP switch is used for testing the A relays of connectors, test group 3. With the switch in the center position (STD), standard 600-ohm-loop pulsing is used; with the switch in the LEAK position, "leak A" pulsing is used; and with the switch in the LOOP position, 1400-ohm-loop pulsing is used.

The BUSY TEST switch is used to perform the busy test on the connectors. The TALK-MON switch is used for talking on or monitoring the circuit under test. An operator's headset or handset plugs into the jacks, shown below the six rotary switches in figure 7-19.

The FLT STP NO PRT-FLT STP PRT switch is used to engage or disengage the printer when a fault is encountered. If you desire a print out of the faults encountered, place the switch in the FLT STP PRT position. Operating the BUSY PRINT OUT switch causes all bypassed busy positions (secondary access switches that were busy) to be printed out. This shows you which areas remain to be tested because the routiner passed over them during testing.

The ADVANCE ACC SW-FAULT RLS switch is a nonlocking lever switch. Moving the lever to the ADVANCE ACC SW position causes the routiner to advance or step the Rotary Access Switch to the next position on its banks. When the switch is moved to the FAULT RLS position, the switch under test releases and the routiner tests the next switch in line. Last, but not least, is the ALM RLS switch which is also a nonlocking switch. Operating this switch silences the audible alarm that sounds when the routiner finds a faulty switch.

Indicator lamps. The top four rows of lamps with numbered jewels (lamp covers), correspond with the rotary switches to the left, that we discussed earlier. The "X" jewels cover lamp positions that are not used. Operating the start switch lights the PRESET lamp, fifth row from the top, far left; and causes the lamps in the top four rows to light, until they indicate the positions of the rotary switches to their left. Once the lamps in the top four rows indicate the start position of the test being performed, the preset lamp goes out. The titles above the other lamp positions are reasonably self-explanatory.

Exercises (069):

State the function(s) of the switches and lamps listed below.

1. ACCESS SWITCH LEVEL, rotary type switch

2. START, lever switch

3. FINDER GROUP, lamps

4. GROUP, rotary type switch

5. "A" LEAK-STD-LOOP, lever switch

6. FLT STP NO PRT, lever switch

7. Busy Test, lever switch

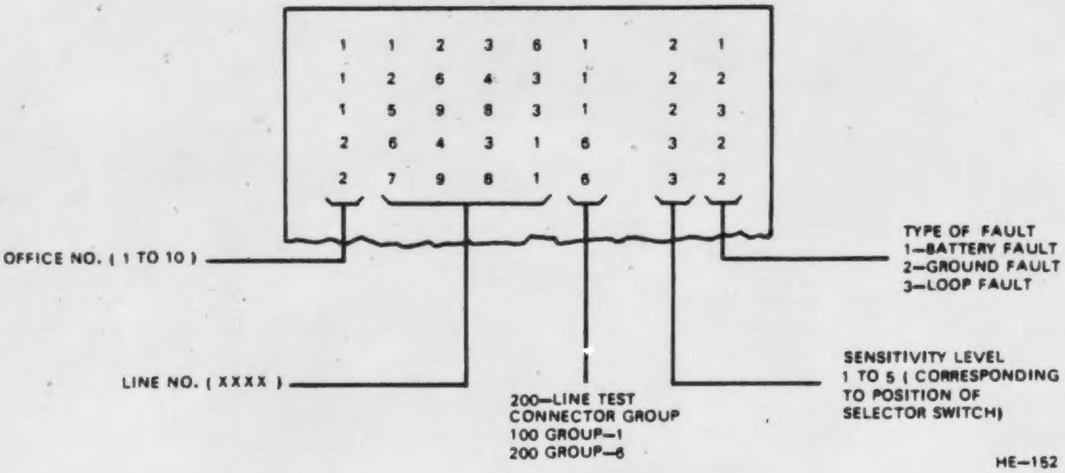


Figure 7-21. Typical line insulation routiner printout.

070. Given print tapes from the line insulation and equipment routiners, interpret specified information.

Printer Tapes. Both the line insulation and equipment routiners come equipped with a printer. It prints out in code the line or specific equipment in trouble and the type of trouble. The only problem with coded printouts is interpreting the code.

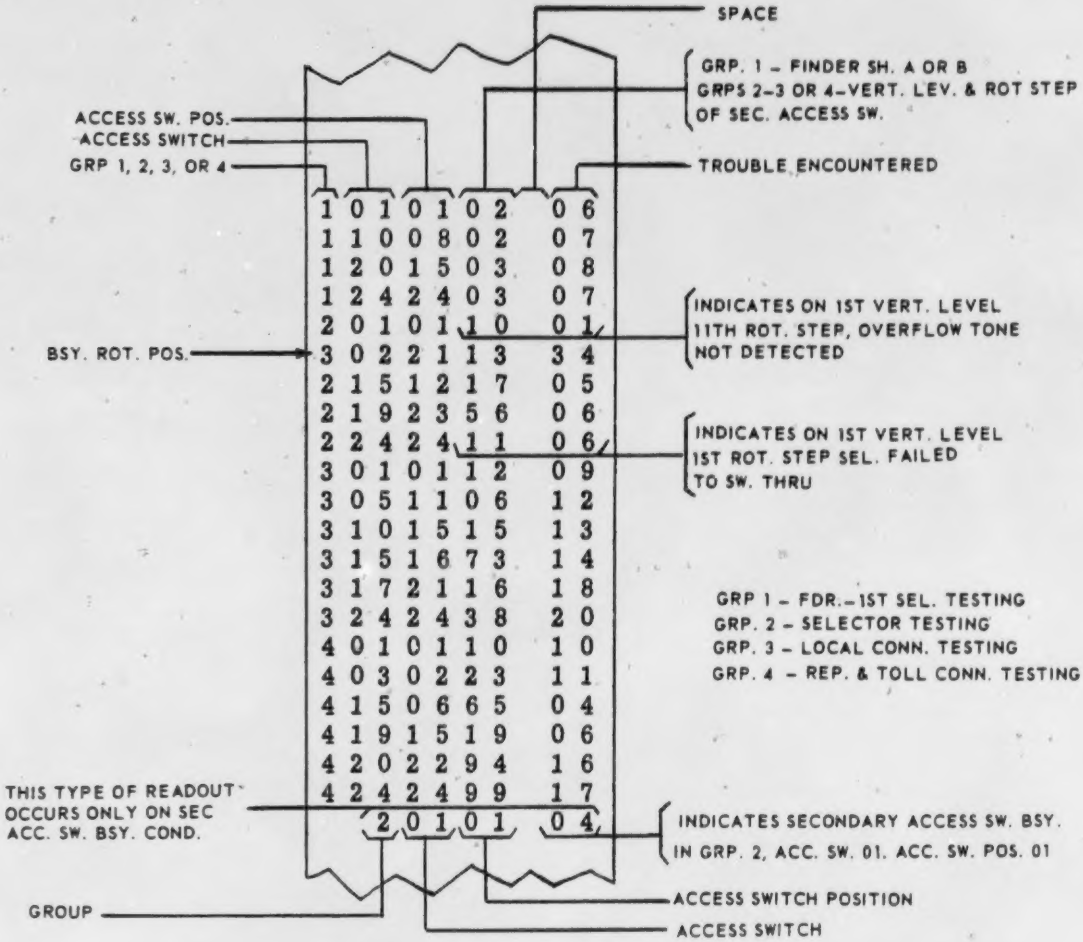
Line insulation routiner printouts. A typical printout from the line insulation routiner is shown in figure 7-21. It is an eight-digit code and contains five pieces of information.

Starting at the left, the first column indicates the number of the exchange being tested. If your base has one or more satellite exchanges, this digit has a significant meaning. The next four digits form the number of the line in trouble. The sixth digit identifies the hundreds group of the line, in relation to connector operation. The seventh digit from the left indicates the sensitivity level at which the test was performed. This corresponds to the setting of the fault sensitivity rotary switches on the test panel.

The last digit indicates the type of fault. If a line has more than one type of fault, each will be printed out on additional separate lines. The trouble codes are as follows:

(1) Battery Fault.
(2) Ground Fault.
(3) Loop Fault.

Equipment routiner printouts. A typical printout from the equipment routiner is shown in figure 7-22. It normally consists of a nine-digit code which contains five pieces of information. In some cases, as shown at the bottom of the figure, the printout is seven-digit code containing four pieces of information.


SPACE
GRP. 1 - FINDER SH. A OR B
GRPS 2-3 OR 4-VERT. LEV. & ROT STEP OF SEC. ACCESS SW.
ACCESS SW. POS.
ACCESS SWITCH
GRP 1, 2, 3, OR 4
TROUBLE ENCOUNTERED
INDICATES ON 1ST VERT. LEVEL 11TH ROT. STEP, OVERFLOW TONE NOT DETECTED
BSY. ROT. POS.
INDICATES ON 1ST VERT. LEVEL 1ST ROT. STEP SEL. FAILED TO SW. THRU
GRP 1 - FDR.-1ST SEL. TESTING
GRP. 2 - SELECTOR TESTING
GRP. 3 - LOCAL CONN. TESTING
GRP. 4 - REP. & TOLL CONN. TESTING
THIS TYPE OF READOUT OCCURS ONLY ON SEC ACC. SW. BSY. COND.
INDICATES SECONDARY ACCESS SW. BSY. IN GRP. 2, ACC. SW. 01. ACC. SW. POS. 01
GROUP
ACCESS SWITCH POSITION
ACCESS SWITCH

```
1 0 1 0 1 0 2   0 6
1 1 0 0 8 0 2   0 7
1 2 0 1 5 0 3   0 8
1 2 4 2 4 0 3   0 7
2 0 1 0 1 1 0   0 1
3 0 2 2 1 1 3   3 4
2 1 5 1 2 1 7   0 5
2 1 9 2 3 5 6   0 6
2 2 4 2 4 1 1   0 6
3 0 1 0 1 1 2   0 9
3 0 5 1 1 0 6   1 2
3 1 0 1 5 1 5   1 3
3 1 5 1 6 7 3   1 4
3 1 7 2 1 1 6   1 8
3 2 4 2 4 3 8   2 0
4 0 1 0 1 1 0   1 0
4 0 3 0 2 2 3   1 1
4 1 5 0 6 6 5   0 4
4 1 9 1 5 1 9   0 6
4 2 0 2 2 9 4   1 6
4 2 4 2 4 9 9   1 7
    2 0 1 0 1   0 4
```

Figure 7-22. Typical equipment routiner printout.

Starting at the left, the first digit indicates the test group; the second and third digits indicate the rotary access switch used, and the fourth and fifth digits indicate the access switch's wiper position in the banks. The sixth and seventh digits indicate: (1) linefinder group tested (A or B) for group 1 tests; or (2) the vertical level and rotary step of the secondary access switch (selector) for group 2, 3, or 4 tests.

The last two digits indicate the type of fault encountered. The 34 different fault codes are listed below.

01: Overflow condition.
02: Linefinder group A.
03: Linefinder group B.
04: Secondary access switch is busy.
05: Selector under test cannot be seized.
06: Selector under test does not switch through.
07: Dial tone not returned by selector under test.
08: Ground is not maintained on lead C during test.
09: Busy tone is not returned during busy test.
10: Connector toll loop is incomplete.
11: Incomplete toll ring circuit is detected.
12: Ring circuit opened during first ring cycle.
13: Ringback tone was not returned.
14: Connector ring circuit opened during first or second ring cycle.
15: Reverse battery was not received from connector on answer.
16: Reversal bridge at distant office was not reached or repeater did not reverse the line polarity.
17: Release cycle not completed.
18: Positive side of transmission loop is open.
19: Negative side of transmission loop is open.
20: Connector under test did not switch through after vertical and horizontal stepping.
21: Not used.
22: Not used.
23: Positive side of transmission line to relay A is open.
24: Negative side of transmission line to relay A is open.
25: Relay A should not operate but did operate.
26: Relay A should operate but did not operate.
27: Dry trunk supervision not provided upon line seizure.
28: Ring circuit did not open during ring trip test.
29: Transmission leads reversed in connector.
30: Positive side of transmission line to relay D is open.
31: Negative side of transmission line to relay D is open.
32: Relay D should not operate but did operate.
33: Relay D should operate but did not operate.
34: Printer is recording the busy positions on a level of secondary access switch.

Exercises (070):

Given the following sample printouts for the line insulation and equipment routiners, interpret the specified codes.

```
1 4 2 1 2 6   2 1
1 6 6 6 1 6   3 3
1 7 3 0 5 1   3 2
1 8 6 7 8 6   3 2
2 2 2 2 2 6   2 1
2 2 3 5 6 1   2 1
2 2 4 7 1 6   3 2
```

Line Insulation Routiner Printout

1. Use the above chart to complete a through e.
   a. List the 7 telephone line numbers.

   b. What number of sensitivity is the Battery Fault sensitivity switch set on?

   c. What number of sensitivity is the GRD-LOOP Fault sensitivity set on?

   d. What hundreds group is each telephone line number in?

   e. List the telephone numbers and state the type of fault found on each.

```
a. 1 0 1 0 1 0 1   2 4
b. 1 0 2 1 0 0 6   1 3
c. 2 0 6 2 0 1 2   2 5
d. 3 1 5 2 1 2 1   0 6
e. 3 1 6 2 0 2 1   3 2
f. 4 1 7 1 5 1 5   1 5
g. 4 1 7 0 9 2 0   1 9
h. 4 4 2 1 5 1 5   2 1
```

Equipment Routiner Printout

2. Use the chart shown above and state the information specified for lines a through h.
   a. Test group and fault.

   b. Access switch and fault.

61

c. Access switch position.

d. Test group and access switch position.

e. Test group, fault, and access switch.

f. Access switch and fault.

g. Secondary access switch position and fault.

h. Test group and access switch.

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

001 - 1.
- a. To cable and antenna.
- b. Cable splicing installation and maintenance specialist.
- c. 5.

001 - 2.
- a. Inside plant.
- b. Electronic Switching System Repairman.
- c. 7.

001 - 3.
- a. Outside plant.
- b. Outside Wire and Antenna Maintenance Repairman.
- c. 3.

001 - 4.
- a. Inside plant.
- b. Telephone Equipment Installer Repairman.
- c. 5.

001 - 5.
- a. Outside plant.
- b. Outside Wire and Antenna Maintenance Technician.
- c. 7.

002 - 1. 7.
002 - 2. 3, 5, and 7.
002 - 3. 3, 5, and 7.
002 - 4. 7.
002 - 5. 3, 5, and 7.

003 - 1. Six months is the minimum time in which OJT to the 5 skill level can be completed.
003 - 2. The task and knowledge requirements for upgrade to the 5 and 7 level are found in the JPG.
003 - 3. The dual channel approach to OJT consists of job proficiency training and completion of the appropriate CDC.
003 - 4. AF Form 2096 must be submitted requesting skill level upgrading.
003 - 5. A JPG is an annotated STS and may also consist of an AF Form 797, listing tasks that do not appear in the STS.

CHAPTER 2

004 - 1. An accident source and an accident cause.
004 - 2. Accident source.
004 - 3. Accident source is defined as an instrument or activity that has a potential of danger. An accident cause is the unsafe act or condition that accompanies the accident source.
004 - 4. Place oily rags in a self-closing metal container.
004 - 5. A common accident caused when measuring the resistance of a circuit is the failure to turn off the power.

005 - 1. Sgt. Johnson failed to get a safety observer in situation 1. He should have had a safety observer because of the high voltage involved (150-amp fuse).

006 - 1.
- a. A1C Smith did not hold the wire wrap gun properly in situation 2. He should have held it level to avoid bending the terminal of the protector.
- b. A1C Smith improperly used the pliers when he stripped the insulation from the jumper at eye level or above in situation 2. He should have gotten a ladder and stripped the insulation from the jumper with pliers below eye level.

007 - 1.
- a. Airman Jones left tools laying on top of the ladder in situation 3. He should have placed the tools in a pocket and taken them to the workbench with him.
- b. Airman Smith, in situation 2, did not get a ladder. He should have gotten a ladder to avoid having to strip the jumper insulation so close to his eyes.

008 - 1. In situation 3 Airman Jones made no provisions to protect himself or his coworkers from the fumes of the cleaning solvent. He should have covered up the cleaning solvent when he wasn't using it. He should also dispose of the oil-soaked rag when he returns from his break.

009 - 1. Airman Jones, in situation 3, failed to put his tools left on the ladder in their proper place. He also left the workbench cluttered with open containers of cleaning solvent and oil. Someone, in situation 3, left dust covers laying in the aisle where they could be tripped over or damaged. The tools left on the ladder should have been stored properly, so that they couldn't fall on someone when the ladder was moved. The containers of solvent and oil should have been capped to keep shop personnel from inhaling the fumes and to keep someone from spilling the oil.

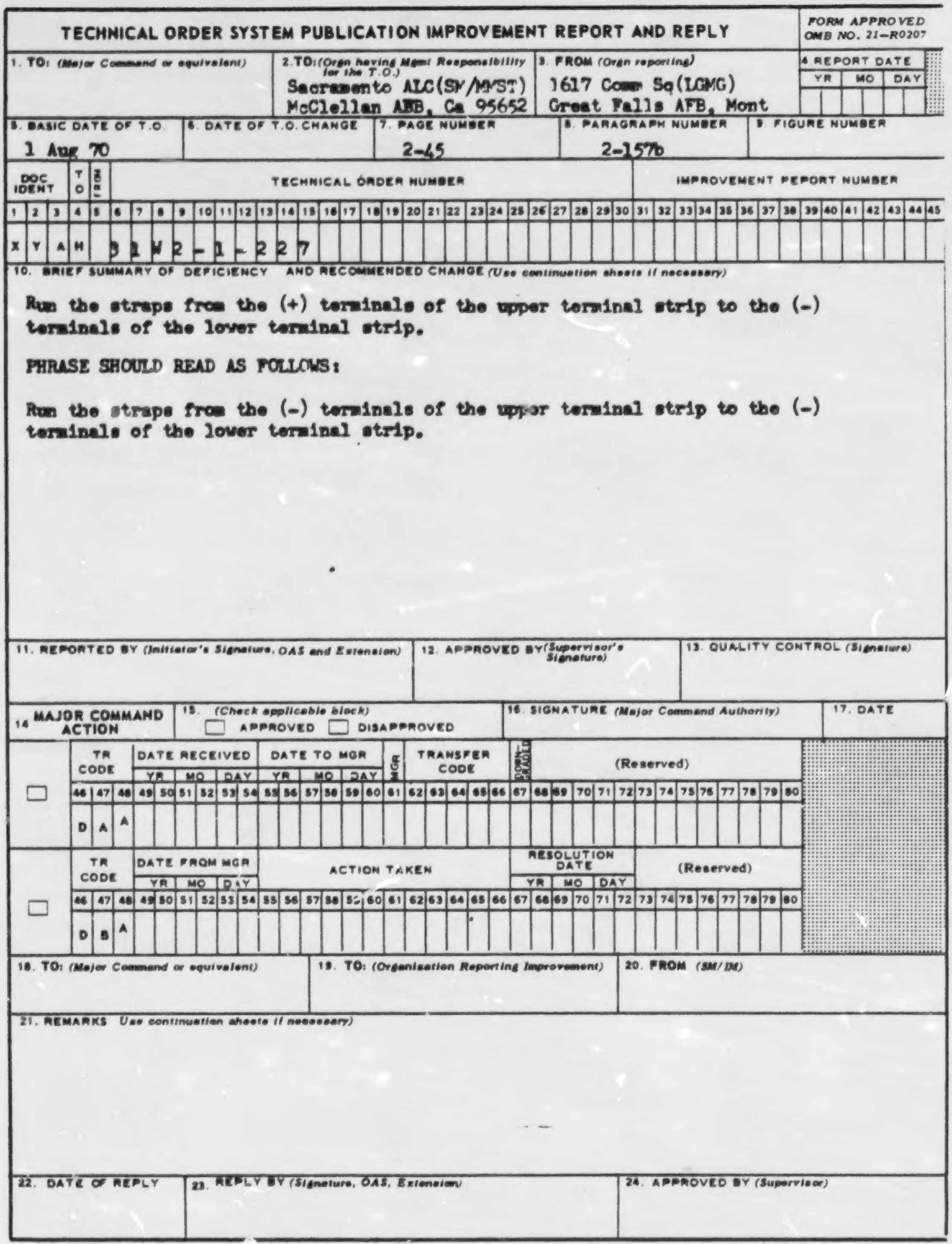
CHAPTER 3

010 - 1. 0-1-15.
010 - 2. 0-1-31-6.
010 - 3. 0-1-35-1.
010 - 4. 0-1-31-8.
010 - 5. (Answer has been deleted.)
010 - 6. 0-1-32.

011 - 1. TO number—31W2-4-1-392; TO date—not published; security classification—U.
011 - 2. TO number—31W2-4-1-343; TO date—1 Jan 1972; security classification—U.
011 - 3. TO number—31W2-4-121-2; TO date—27 Dec 1965; security classification—U.
011 - 4. TO number—31W2-4-120-2; TO date—1 Jun 1970; security classification—U.

012 - 1. Page No. 1-56 Paragraph No. 1-147.
012 - 2. Page No. 1-13 Paragraph No. 1-106, and page No. 1-10 Paragraph No. 1-78.
012 - 3. Page No. 1-6 Paragraph No. 1-33.
012 - 4. Page No. 1-72 Paragraph No. 1-187.
012 - 5. Page No. 1-78 Paragraph No. 1-193.

013 - 1. See figure 1.



TECHNICAL ORDER SYSTEM PUBLICATION IMPROVEMENT REPORT AND REPLY

FORM APPROVED
OMB NO. 21–R0207

1. TO: (Major Command or equivalent)

2. TO: (Organ having Mgmt Responsibility for the T.O.)
Sacramento ALC(SM/MMST)
McClellan AFB, Ca 95652

3. FROM (Organ reporting)
1617 Comm Sq(LGMG)
Great Falls AFB, Mont

4. REPORT DATE YR MO DAY

5. BASIC DATE OF T.O.: 1 Aug 70

6. DATE OF T.O. CHANGE

7. PAGE NUMBER: 2-45

8. PARAGRAPH NUMBER: 2-157b

9. FIGURE NUMBER

DOC IDENT			TO	CHG	TECHNICAL ORDER NUMBER	IMPROVEMENT REPORT NUMBER
1	2	3	4	5	6–30	31–45
X	Y	A	H		31W2-1-227	

10. BRIEF SUMMARY OF DEFICIENCY AND RECOMMENDED CHANGE (Use continuation sheets if necessary)

Run the straps from the (+) terminals of the upper terminal strip to the (-) terminals of the lower terminal strip.

PHRASE SHOULD READ AS FOLLOWS:

Run the straps from the (-) terminals of the upper terminal strip to the (-) terminals of the lower terminal strip.

11. REPORTED BY (Initiator's Signature, OAS and Extension)

12. APPROVED BY (Supervisor's Signature)

13. QUALITY CONTROL (Signature)

14 MAJOR COMMAND ACTION

15. (Check applicable block) ☐ APPROVED ☐ DISAPPROVED

16. SIGNATURE (Major Command Authority)

17. DATE

	TR CODE			DATE RECEIVED YR		MO		DAY		DATE TO MGR YR		MO		DAY		MGR	TRANSFER CODE					DOWNGRADED	(Reserved)												
☐	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
	D	A	A																																

	TR CODE			DATE FROM MGR YR		MO		DAY		ACTION TAKEN												RESOLUTION DATE YR		MO		DAY		(Reserved)							
☐	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
	D	B	A																																

18. TO: (Major Command or equivalent)

19. TO: (Organization Reporting Improvement)

20. FROM (SM/IM)

21. REMARKS Use continuation sheets if necessary)

22. DATE OF REPLY

23. REPLY BY (Signature, OAS, Extension)

24. APPROVED BY (Supervisor)

AFTO FORM APR 73 22

REPLACES AFTO FORMS 22 AND 22A WHICH ARE OBSOLETE

Figure 1. AFTO Form 22 (answer for objective 013, exercise 1).

014 - 1. Sgt Smith should have annotated the AFTO Forms 110 for each tech order with a minus (−) sign: he should also have annotated the requisitions section of each card with the TO number, date and number of the requisition, and the number of TOs requisitioned.

014 - 2. The AFTO Form 110 cards for all five tech orders should have the distribution record section on the back annotated. The minus (−) on the front of each card should be changed to a plus (+).

014 - 3. The AFTO Form 110 card for each NI&RT should be annotated to reflect the check was made, the date it was made, and Sgt James' signature.

CHAPTER 4

015 - 1.
- a. Receive the new worker. Review his work experience, education, and training.
- b. Welcome the new worker. Make him feel at home and welcome. Assign him his tools.
- c. Show an interest in him. Ask if he is settled, having problems. Discuss his interests, background and family.
- d. Explain the work of the unit. Outline the structure of the organization and its mission. Explain where he fits into the structure of the unit.
- e. Introduce him to shop personnel. Familiarize him with what the others do and the others with what the new worker will be doing.
- f. Show him the shop layout and available facilities. Familiarize him with the equipment room and administration area as well as the snack bar, break room, and latrine.
- g. Explain the rules and regulations. State his duty hours, lunch hour, breaks, etc. Also, cover fire regulations, where smoking is permitted, and important safety items.
- h. Assign him to a shift. If possible, assign the new worker to the shift desired; but take his abilities, the shop needs, and the training the worker requires into the decision.

015 - 2. The shop-needs and new worker's needs.

016 - 1. a, c.
016 - 2. b, d.
016 - 3. b, d.
016 - 4. a, c.

017 - 1.
- a.
  - 6 Inspect MDF.
  - 7 Inspect records.
  - 4 Cut grass and police area.
  - 3 Routine selectors, connectors, and repeators.
  - 5 Clear and lubricate linefinders.
  - 2 Install 15 two-wire circuits.
  - 1 Reroute circuits from base headquarters.
- b.
  - Priority 1—Base headquarters circuits affect the mission of the entire base.
  - Priority 2—New circuits, with a deadline assigned show an obvious importance.
  - Priority 3—The PMIs are the backbone of quality of telephone service.
  - Priority 4 — Cutting the grass requires only one man and there is a short suspense for the inspection.
  - Priority 5—This is a PMI, not as important as the other PMIs; but needs doing so that the entire schedule isn't deferred.
  - Priority 6—Inspecting the MDF is an in-house type of inspection.
  - Priority 7—Inspecting records affects the service less than any of the listed duties.

018 - 1. Define the problem.
018 - 2. Get the facts.
018 - 3. Weigh and decide on the best course of action.
018 - 4. Evaluate the action taken. This is done to determine if the problem is solved.

019 - 1.
- (1) Airman Performance Report. It is used in selective retention, assignment selection, and the Weighted Airman Promotion System (WAPS).
- (2) Skill Level Upgrading. It helps to check on a person's overall training and prompt upgrading.
- (3) Job Proficiency Evaluation. It helps to insure standardized, high quality maintenance.

020 - 1. c.
020 - 2. b.
020 - 3. a.
020 - 4. b.
020 - 5. c.
020 - 6. a.

021 - 1. The purpose of the classification system is to match job requirements with people who possess the necessary aptitudes and abilities to do the jobs.

021 - 2. To get the best use of personnel resources.

022 - 1.
- a. Work satisfactorily as a 7 level for a minimum of 1 year.
- b. Successfully complete all training requirements including management as outlined in AFM 50-23.
- c. Be a SSgt or above.
- d. Be recommended by supervisor.

022 - 2.
- a. To put personnel on OJT.
- b. For recommending upgrade in skill level.

022 - 3.
- a. Qualify as a bypassed specialist.
- b. Complete formal, 3-level, training course.
- c. Satisfactorily perform in the 3 level, successfully complete all training requirements, pass AKT or 3-level CDC.

023 - 1.

a.	Cord, wiper	2	1	16
b.	Contact Assy, Elec	1	1	15
c.	Double Dog	1	1	3
d.	Fuse, Ind Alm, 1.33A	10	15	300
e.	Spring Assy, VON	2	1	2
f.	Bracket, Clamp	4	1	6

023 - 2. AF Form 2005, Issue/Turn-In Request.

023 - 3. The first two identify the group; the next two identify classes within the group; the final seven digits are the NIIN.

023 - 4. When you don't know the NSN. From the -4 tech order for your exchange.

024 - 1. d.
024 - 2. f.
024 - 3. a.
024 - 4. c.
024 - 5. b.
024 - 6. e.

025 - 1. b.
025 - 2. c.
025 - 3. a.
025 - 4. b.
025 - 5. c.

025 - 6. b.
025 - 7. a.
025 - 8. b.
025 - 9. a.
025 - 10. c.
025 - 11. b.
025 - 12. a.

026 - 1. Action by the supervisor to prevent violations of organizational policy.
026 - 2.
- a. Inspect or check.
- b. Test or verify.
- c. Guide.
- d. Limit.

027 - 1.
- a. To insure that the right quality and quantity of work is accomplished.
- b. To insure that work is done on time.
- c. To keep waste and inefficiency to a minimum.
- d. To check on work progress.
- e. To determine if work is going according to plan.
- f. To determine whether the approved or best methods are employed.

028 - 1. c.
028 - 2. f.
028 - 3. a.
028 - 4. b.
028 - 5. d.
028 - 6. e.
028 - 7. c.
028 - 8. b.
028 - 9. a.
028 - 10. f.
028 - 11. e.
028 - 12. d.

029 - 1. F.
029 - 2. F.
029 - 3. T.
029 - 4. T.
029 - 5. T.

030 - 1. c.
030 - 2. a.
030 - 3. b.

031 - 1. S.
031 - 2. T.
031 - 3. T.
031 - 4. S.
031 - 5. S.
031 - 6. T.
031 - 7. T.
031 - 8. S.

032 - 1. e.
032 - 2. c.
032 - 3. a.
032 - 4. d.
032 - 5. b.
032 - 6. c.
032 - 7. e.
032 - 8. a.
032 - 9. d.
032 - 10. b.

033 - 1. f.
033 - 2. d.
033 - 3. i.
033 - 4. a.
033 - 5. b.
033 - 6. e.
033 - 7. g.
033 - 8. c and d.
033 - 9. h.

034 - 1. STS.
034 - 2. 797.
034 - 3. 623.
034 - 4 STS.
034 - 5. A circle around the proficiency code.
034 - 6. The supervisor, in the JPG.
034 - 7. AFM 50-23.
034 - 8. ECI Form 9.
034 - 9. ECI Form 9.
034 - 10. ECI Form 9.

035 - 1.
- a. Examine program objectives. Determine if the program meets your needs; if all the necessary and no unnecessary training is being given.
- b. Examine training methods. Determine if the training: is geared to individuals; is interesting; involves the trainees.
- c. Examine results. Evaluate the people against the tasks they have been trained on.

CHAPTER 5

036 - 1. A functional element of the organization, responsible for insuring that Air Force material is serviceable, safely operable, and properly configured to meet the mission requirements.
036 - 2. Inspection, repair, overhaul, modification, preservation, testing, condition or performance analysis, and completion of tasks on a preplanned, scheduled basis.

037 - 1. b.
037 - 2. a.
037 - 3. b.
037 - 4. a.
037 - 5. c.
037 - 6. c.

038 - 1. To improve maintenance quality and capability, and to achieve technician competence.
038 - 2. Training you to use standard maintenance practices to comply with technical data, and by periodically evaluating you by highly qualified technicians.
038 - 3. His supervisor.
038 - 4. The supervisor and quality control personnel.
038 - 5. Primary, follow-on, and special.

039 - 1. All maintenance equipment has been secured or released to another individual or crew.
039 - 2. A minimum of 8.
039 - 3. Chief of Maintenance.

040 - 1.
- a. Maintenance Superintendent.
- b. Production Analysis.
- c. Training Management.
- d. Administration.
- e. Programs—Mobility.

040 - 2. A maintenance supervisor may be required for two or more work centers. In some CEM units, several maintenance supervisors may be required.
040 - 3. Telemetry, photographic, photo-optics, instrumentation, AFRTS (Armed Forces Radio and Television Services), training equipment, special maintenance teams, centralized intermediate level maintenance, and laboratory.

66

040 - 4. a. Inspection.
b. Deficiency Analysis.
c. Evaluation.
d. Deficiency Reporting.
e. Technical Order File.
040 - 5. Authorized only for units supporting Minuteman.

041 - 1. a. Quality control.
b. Maintenance supervision.
c. Maintenance control.
d. Minuteman missile cable affairs.
041 - 2. a. Maintenance superintendent.
b. Production analysis.
c. Training management.
d. Administration.
e. Programs and mobility.
041 - 3. Maintenance complex means all staff functions, management support functions, and maintenance activities directly or functionally responsible to the Chief of Maintenance.
041 - 4. Maintenance activities are radar, computer, communications, AGE, navigational aids, meteorological, PMEL, television, and other functions.
041 - 5. Major responsibilities are planning, scheduling, controlling, and executing the maintenance functions.

042 - 1. a.
042 - 2. a.
042 - 3. b.
042 - 4. b.
042 - 5. c.
042 - 6. c.
042 - 7. c.
042 - 8. c.

043 - 1. d.
043 - 2. e.
043 - 3. c.
043 - 4. b.
043 - 5. a.
043 - 6. b.
043 - 7. c.
043 - 8. e.
043 - 9. d.
043 - 10. a.

044 - 1. F.
044 - 2. F.
044 - 3. T.
044 - 4. T.
044 - 5. T.
044 - 6. F.

045 - 1. (a) So that the same deficiencies can be corrected on like equipment at other installations and (b) improvements can be made in design, test, and modification programs.
045 - 2. Category I Report.
045 - 3. As a combination Category I Report and *DULL SWORD*.
045 - 4. Category II Report.
045 - 5. A means of obtaining the Air Force's evaluation of the quality of work performed by contractors and specialized repair activities.
045 - 6. TO deficiencies are reported under the TO improvement program.
045 - 7. Quality control.

046 - 1. The purpose of PMIs is to discover and fix conditions which could lead to malfunctions requiring major repair.
046 - 2. Preventive maintenance.
046 - 3. Workcards contain a statement of job purpose; a listing of all tools, test equipment, and materials required; step-by-step instructions for doing the job, frequency of the routine, time needed, and power condition.
046 - 4. The Chief of Maintenance; he may shorten or lengthen intervals between inspections, but interval will not exceed that shown on workcards.
046 - 5. The three types of inspections performed by quality control are (1) technical, (2) activity, and (3) special. Technical inspections are made to determine if the equipment is being maintained to meet TO specifications. Activity inspections are made to determine the quality of management of the maintenance activity. Special inspections are made to provide maintenance supervisors or managers information on one-time situations of either administrative or technical nature.
046 - 6. Quality control inspection reports are routed through supervisory channels to deficiency analysis. All activity inspection reports will be additionally routed through the Chief of Maintenance.
[046 - 7. A completed AFTO Form 349.] Delete

047 - 1. The maintenance data collection system provides information such as what job was done, who did the job, when it was done, number of direct man-hours consumed for a job, why the job was necessary, when the malfunction was discovered and what work center performed the work to management.
047 - 2. A job that has a definite beginning and end, the accomplishment of which requires expenditure of direct labor.

048 - 1. a. Administrators and supervisors are able to analyze and evaluate their operations.
b. Work center supervisors are helped in managing their shops and in increasing their effeciency.
c. Chief of Maintenance and staff use this information manpower planning, forecasting tool and equipment needs, budget computations, and cost analysis.
d. AFLC uses this data for inspection and maintenance requirements analysis, master repair schedules, deficiency analysis, and costs.

049 - 1. AFTO Form 349 and AFTO Form 350.
049 - 2. AFTO Form 349 used to report all on-equipment and off-equipment maintenance actions, and all work directed time compliance TOs. AFTO Form 350 attached to item when it is removed and taken to the shop or repair depot.

050 - 1. d.
050 - 2. c.
050 - 3. a.
050 - 4. b.
050 - 5. c.
050 - 6. d.
050 - 7. a.
050 - 8. b.
050 - 9. d.
050 - 10. a.
050 - 11. b.
050 - 12. c.

051 - 1. i.
051 - 2. k.
051 - 3. a.
051 - 4. c.
051 - 5. g.
051 - 6. n.
051 - 7. j.

051 - 8. f.
051 - 9. d.
051 - 10. m.
051 - 11. b.
051 - 12. l.
051 - 13. e.
051 - 14. h.

052 - 1. 1.
052 - 2. 3/24.
052 - 3. B.
052 - 4. 5.
052 - 5. F.
052 - 6. F.
052 - 7. 4.
052 - 8. C.
052 - 9. 25.
052 - 10. 29.

052 - 11. 19/29.
052 - 12. 20/9.
052 - 13. 24.
052 - 14. 26.

Delete

CHAPTER 6

053 - 1. e.
053 - 2. d.
053 - 3. b.
053 - 4. a.
053 - 5. c.
053 - 6. f.

054 - 1, -2, -3, -4, -5. See figure 2.

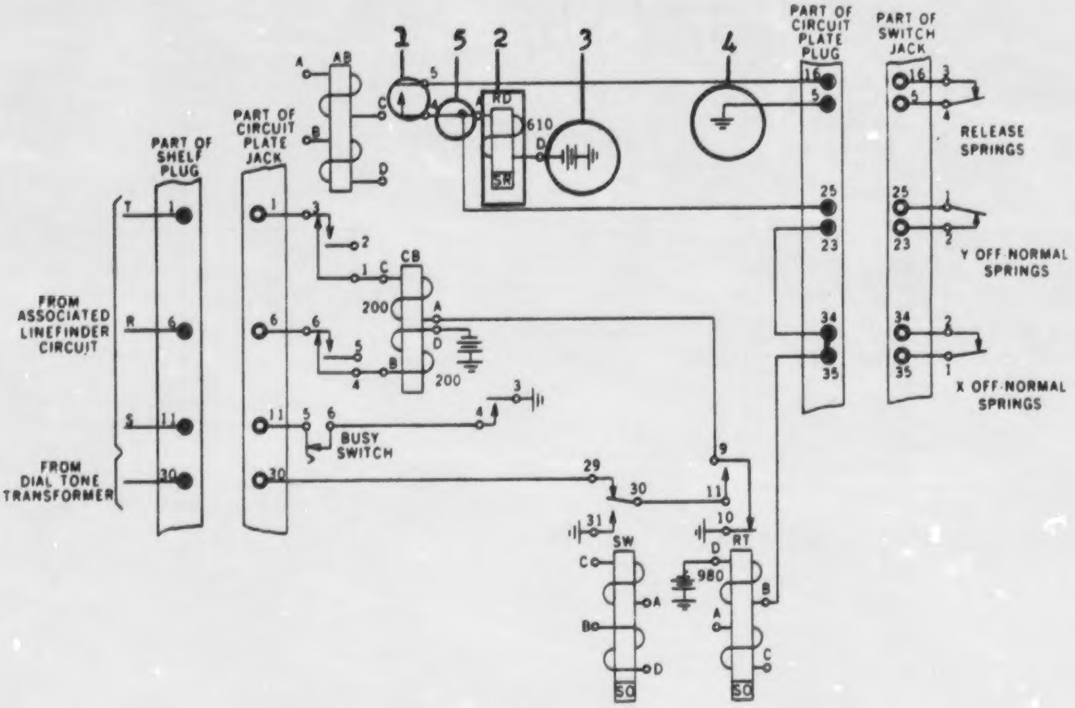


Figure 2. Simplified operating circuit for relays CB, RD, and RT. (answer for objective 054, exercises 1 through 5).

055 - 1. $E = IR, I = \frac{E}{R}, R = \frac{E}{I}$
056 - 1. 80 volts.
056 - 2. R_T = 4 ohms, I_2 = 2 amps, $R_1 + R_2$ = 6 ohms, lamp + R_3 = 12 ohms.
056 - 3. I_T = 5 amps.
L_2 = 50 ohms.
I_3 = .75 amp.
L_4 = 300 ohms.
R_T = 20 ohms.
056 - 4. R_1 = 4 ohms
E_2 = 3 volts.
R_3 = 38 ohms.
E_3 = 19 ohms.
056 - 5. R_1 = 20 ohms.
I_2 = .1 amp.
R_3 = 21.4 ohms.
I_3 = 1.4 amps.
R_T = 10 ohms.

057 - 1. 6,000,000 meters.
057 - 2. F = 4 kHz, λ = 75,000 meters.
057 - 3. F = 5 MegHz, T = .2 microsecond.
057 - 4. T = .02 millisec., λ = 6,000 meters.
057 - 5. F = 400 kHz, T = 2.5 microsecs.
057 - 6. F = 250 Hz, λ = 1,200,000 meters.

058 - 1. Frequency and inductance.

058 - 2. Increases.
058 - 3. Increases.
058 - 4. Decreases.
058 - 5. Increases.
058 - 6. Decreases.
058 - 7.
  a. Decreases.
  b. Decreases.
  c. Decreases.

059 - 1. Leading.
059 - 2. Increased.
059 - 3. Decreased.
059 - 4.
  a. No changes.
  b. Decreases.
  c. Decreases.

059 - 5. Decreases.
059 - 6.
  a. Increases.
  b. Increases.

060 - 1.
  a. Electrons.
  b. Holes.
060 - 2. Current flows freely.
060 - 3. Positive to P contact, negative to N contact.
060 - 4. Every other alternations of input voltage.
060 - 5. Same.
060 - 6. Reverse.
060 - 7. Every alternation is of same polarity, ripple frequency is twice that of input voltage.

061 - 1. Emitter. Emits current carriers.
Base. Controls the flow of current carriers.
Collector. Collects current carriers.
061 - 2. Emitter-base.
061 - 3. By an arrow.
061 - 4. Base.
061 - 5. Emitter to collector.

062 - 1.
  a. Common-base.
  b. Common-emitter.
  c. Common-collector.
062 - 2. R_3.
062 - 3. The transistor.

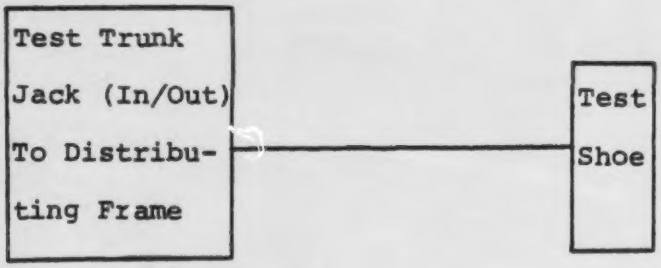
063 - 1. CE.
063 - 2. CB.
063 - 3. CC.
063 - 4. CB CE.
063 - 5. CC.
063 - 6. CB.
063 - 7. CC CB.
063 - 8. CE.

CHAPTER 7

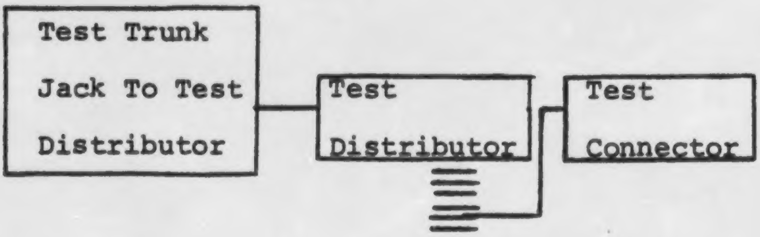
064 - 1. With the clip of the test receiver connected to ground and the test probe placed on contact 6T of relay H, ringing should be heard.
064 - 2. With the clip of the test lamp connected to ground and the test probe placed on contact 6T of relay H, the test lamp will light brightly and flicker at a frequency of 20 hertz.
064 - 3. With the clip of the test lamp connected to battery, placing the test probe to contact 8T of relay H causes the lamp to light its brightest, while touching it to contact 11 of relay D causes it to light; but not as brightly. The difference is caused because between contact 11 of relay D and ground is 200 ohms resistance and there is no resistance between contact 8T of relay H and ground.
064 - 4. If the clip of the test lamp is connected to ground and the test probe is placed on contact 3 of the A relay of a seized connector no indication will be seen.

065 - 1. The three main components of a test telephone handset are the receiver, transmitter, and dial.
065 - 2. Depressing the C push-switch removes the transmitter and dial from the circuitry of the test telephone handset leads.
065 - 3. Depressing the R push-switch adds 1200 ohms series resistance to the test telephone handset leads.
065 - 4. With the test telephone handset plugged into test jack 1 and 2 of the connector:
  a. With the C push-switch operated, the connector will remain idle.
  b. With the R push-switch operated, the connector will be seized, and if pulsed, the extreme loop pulsing limits of the A relay will be tested.
  c. With no push-switches operated, the connector will be seized and ready for pulsing.
065 - 5. Depressing the R push-switch when testing selectors or connectors tests the A relay pulsing under extreme loop resistance conditions.
065 - 6. You use the C push-switch to monitor a circuit or to release a circuit you have seized.

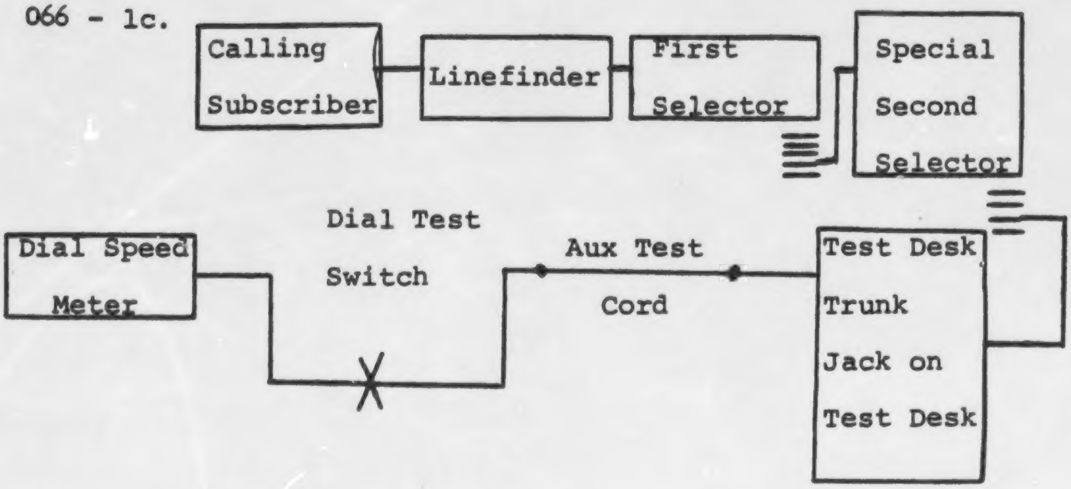
066 - 1a.



066 - 1b.



066 - 1c.



066 - 2a. The function of the 15V-150V switch is to connect the desired amount of test battery in series with the meter.

066 - 2b. The function of the PRIM TALK-RING switch is to connect ringing current to the primary test cord circuit when in the RING position; and connect the operator's transmitter and receiver to the primary test cord circuit when in the PRIM TALK position.

066 - 2c. The function of the CALL THRU-TCO switch in the TCO position is to cut off the transmitter for monitoring on the test cord circuits; in the CALL THRU position it permits the operator to use the line equipment, of the line under test, to dial any number in the exchange.

066 - 2d. The function of the RING REV-SW switch in the SW position switches the primary and the auxiliary test cord circuits with respect to the two rows of lever switches; in the RING REV position it reverses the tip (+) and ring (−) conductors of the primary and auxiliary test cords in the test circuit.

066 - 2e. The function of the OHM HI switch is to connect the volt-ohm-milliammeter for resistance measurements using the lightest resistance range.

066 - 2f. The function of the 150 MA-BCO switch in the 150 MA position is to connect the test desk meter for reading current; in the BCO position it permits the test desk operator to use the line equipment of the line under test, through the test distributor trunk, to dial a

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number. It is used in conjunction with the CALL THRU switch.

066 - 2g. The function of the CT switch is to permit testing of line capacitance automatically without using the RING REV switch. It works in conjunction with the 15V-150V switch.

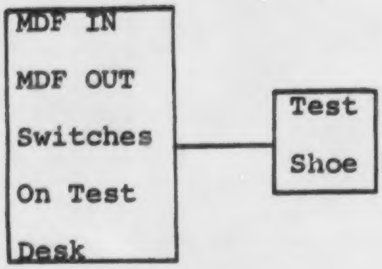
066 - 2h. The function of the HOWL lever switch is to connect the howler to the auxiliary test cord circuit for use in signaling station where receiver has not been replaced on hook. Operation to the DIAL TEST position connects the dial speed and pulse ratio test circuit to the auxiliary test cord circuit for testing dials.

066 - 2i. The function of the NA switch is to enable the night alarm buzzer when the test desk is unattended.

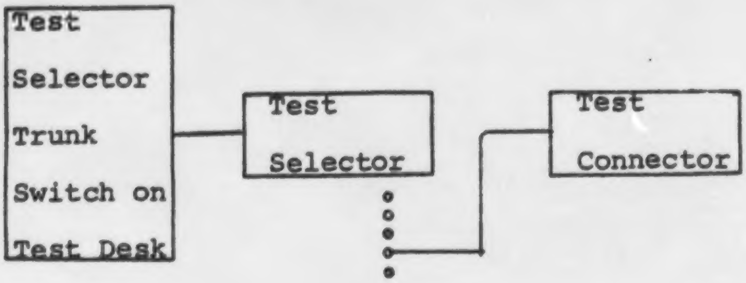
066 - 2j. The function of the cords is to connect the test circuits of the test desk to the various test trunks.

066 - 2k. The function of the relay gate is to mount the relays and components of the test circuits.

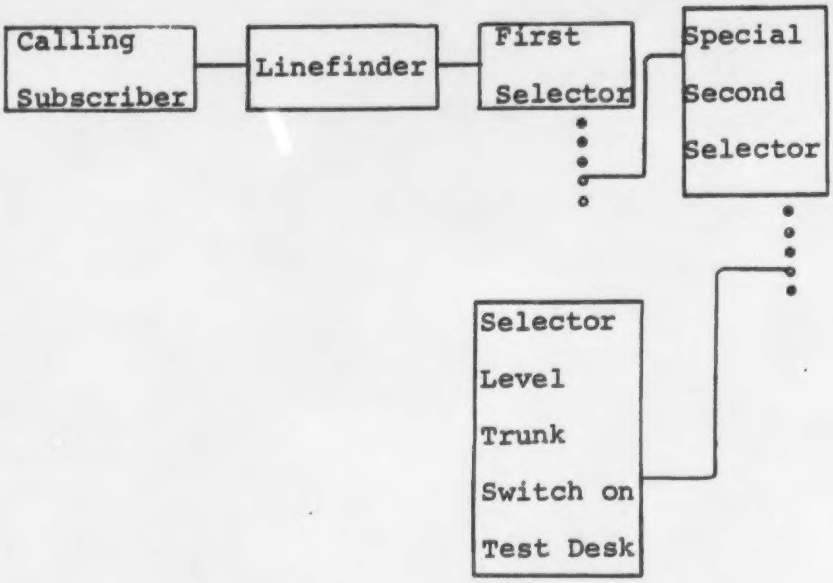
067 - 1a.



067 - 1b.



067 - 1c.



067 - 2a. The function of the MDF IN switch is to connect the test shoe, the half that tests from the jumper side of the protector, to the test desk testing circuit.

067 - 2b. The function of the TEST SEL TRK switch is to connect the telephone line that a repairman is calling into the test desk on, to the test desk testing circuit.

067 - 2c. The function of the Release Permanent switch is to release line equipment which is held operated because of a permanent condition.

067 - 2d. The function of the Loop switch is to condition the test circuit to give a reading on the test desk meter if the line under test is shorted.

067 - 2e. The function of the Tip Ground switch is to condition the test circuit to give a reading on the test desk meter if the tip side of the line under test is grounded.

067 - 2f. The function of the Ring Battery switch is to permit testing for 0 to 150 volts of battery on ring.

067 - 2g. The function of the HEAT COIL switch is to permit testing of the inside plant equipment from the MDF through the heat coil.

068 - 1. The function of the PRESET switch is to seize the central office test distributor.

068 - 2. The function of the AUX SIG switch is to connect a buzzer in the alarm circuit.

068 - 3. The function of the BAT FAULT SENSITIVITY switch permits selection of five sensitivity ranges.

068 - 4. The function of the CAMP ON FAULT switch, when operated is to cause the routiner to stop and bring in an alarm when a fault is found.

068 - 5. The function of the GRD CALIB-BAT CALIB switch is to permit adjustment of sensitivity of the fault detection circuits and is used in conjunction with the DL-BL switch.

068 - 6. The function of the THOUS STEP-HUND STEP switch is to permit stepping of the rotary access switches to a specific number group to be tested.

069 - 1. The function of ACCESS SWITCH LEVEL switch is to permit selection of a specific selector or linefinder group connected to the banks of a rotary access switch.

069 - 2. The function of the START switch is to start the routiner.

069 - 3. The function of the FINDER GROUP lamps is to indicate which linefinder group of the shelf under test is being tested.

069 - 4. The function of the GROUP switch is to permit selection of the equipment to be tested.

069 - 5. The function of the "A" LEAK-STD-LOOP switch is to permit selection of the type of pulsing used during group 3 testing.

069 - 6. The function of the FLT STP NO PRT switch in that position is to disengage the printer from the routiner circuits.

069 - 7. The function of the Busy Test switch is to permit busy testing only of the connectors.

070 - 1a. The seven line numbers are 4212, 6661, 7305, 8678, 2222, 2356, and 2471.

070 - 1b. The Battery Fault sensitivity switch is set on 2.

070 - 1c. The GRD-LOOP Fault sensitivity switch is set on 3.

070 - 1d. 4212, 6661, 8678, 2222, and 2471 are in the 200 group. 7305 and 2356 are in the 100 group.

070 - 1e. 4212, 2222, and 2356 have battery faults. 7305, 8678, and 2471 have ground faults. 6661 has a short line.

070 - 2a. Test group 1; linefinder-first selectors fault 24; positive side of transmission line to relay A is open.

070 - 2b. Access switch 2. Fault 13; ring back tone not returned.

070 - 2c. Access switch 6; wipers positioned on bank contact 20.

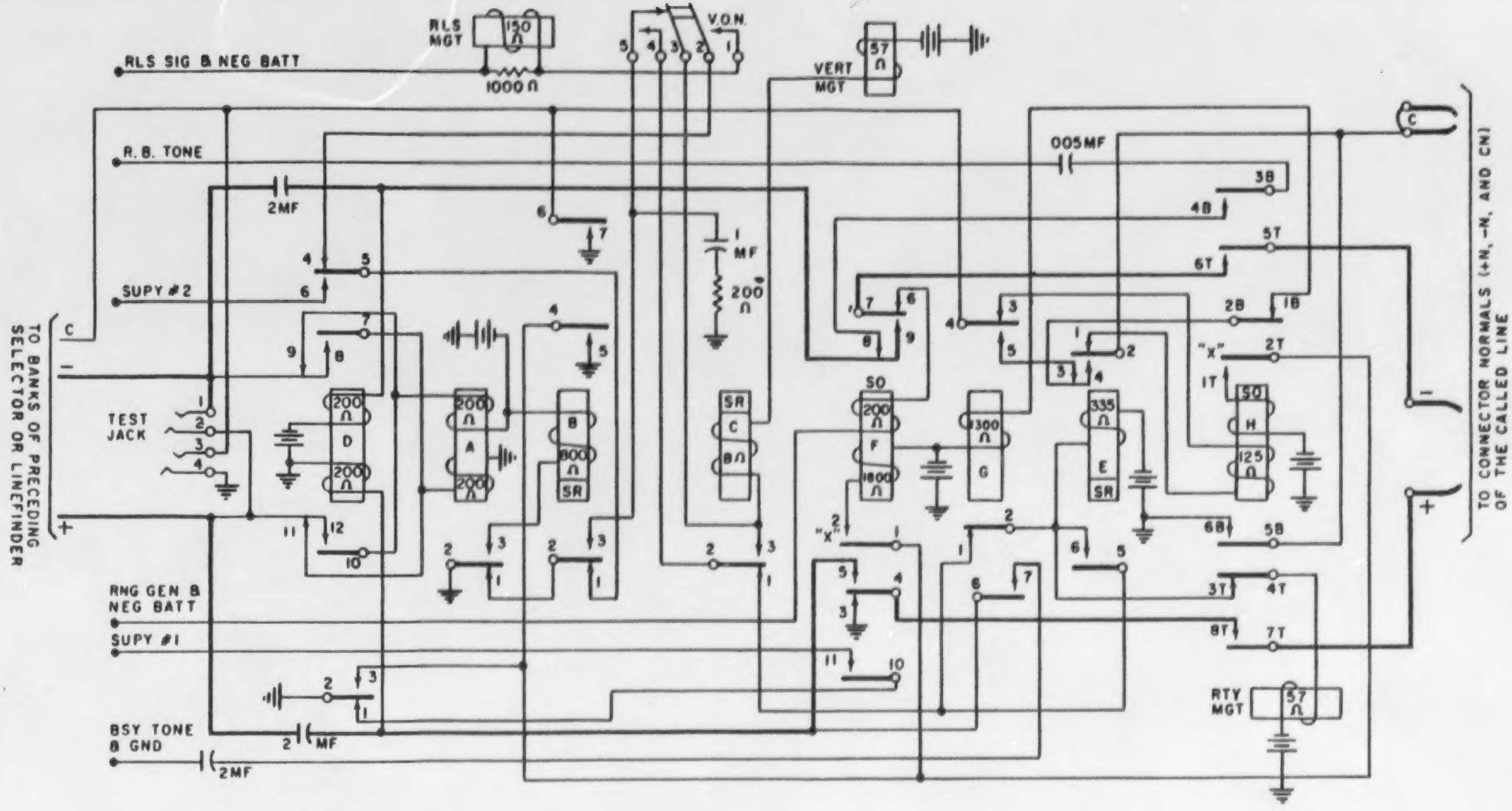
070 - 2d. Test group 3; connectors. Access switch 15; wipers positioned on bank contact 21.

070 - 2e. Test group 3; connectors. Fault 32; relay D should not operate, but did. Access switch 16.

070 - 2f. Access switch 17. Fault 15; reverse battery was not received from the connector on answer.

070 - 2g. Access switch 17, wipers positioned on bank contact 9. Secondary access switch wipers positioned on vertical or X 2, rotary or Y 0. Fault 19; negative side of transmission loop is open.

070 - 2h. Test group 4, trunk circuits. Access switch 42.



NOTES

1 "X" CONTACTS OF RELAYS F AND H MAKE FIRST

2 SUPY NO 1 AND SUPY NO 2 LEADS EACH EXTEND THROUGH A SUPERVISORY LAMP TO NEGATIVE BATTERY

3 RELAY F OPERATES ONLY WHEN DIRECT CURRENT OR DIRECT CURRENT SUPERIMPOSED WITH ALTERNATING CURRENT FLOWS THROUGH ITS 200-OHM WINDING

Foldout 1. 100-point step-by-step connector.

STOP - **1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.**
2. USE NUMBER 2 PENCIL ONLY.

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

36251 01 25
INTRODUCTION TO CAREER FIELD

Carefully read the following:

DO's:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you have to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If mandatorily enrolled student, process questions or comments through your unit trainer or OJT supervisor. If voluntarily enrolled student, send questions or comments to ECI on ECI Form 17.

DON'Ts:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: **NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE.** In parenthesis after each item number on the VRE is the Learning Objective Number where the answer to that item can be located. When answering the items on the VRE, refer to the Learning Objectives indicated by these Numbers. The VRE results will be sent to you on a postcard which will list the actual VRE items you missed. Go to the VRE booklet and locate the Learning Objective Numbers for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

MULTIPLE CHOICE

1. (001) What AFSC must you have to be promoted to E-6?

   a. 36231.
   b. 36251.
   c. 36271.
   d. 36390.

2. (003) A 5-skill level airman is expected to be proficient in which of the following?

   a. All the tasks listed in column 1 that are coded in column 3A of the STS.
   b. Those tasks that are coded and circled in column 3A of the STS.
   c. Those tasks that are identified in the JPG.
   d. All the tasks listed on AF Form 797.

3. (003) Study references for your OJT are listed in

   a. AFM 39-1.
   b. the JPG and STS.
   c. a career field chart.
   d. the specialty description.

4. (003) What form is used to request skill level upgrade?

   a. AF Form 2095.
   b. AF Form 797.
   c. AF Form 623.
   d. AF Form 2096.

5. (004) What is the most frequent cause of accidents?

   a. Natural phenomena.
   b. Physical hazards.
   c. Human error.
   d. Careless housekeeping.

6. (004) Ohmmeters have been damaged frequently because of

   a. local maintenance operating instructions.
   b. having to operate them according to regulations.
   c. failure to zero the meter prior to testing the circuit.
   d. failure to disconnect the power source of the circuit being tested.

7. (005) Metallic chips and scraps of wire should not remain on insulating mats because they could

   a. reduce the insulating value of the mat.
   b. contribute to poor housekeeping habits.
   c. eliminate the insulating value of the mat.
   d. make the matting slick in spots.

8. (009) Which statement best describes the importance of good housekeeping practices?

   a. Dust covers and test equipment do not get damaged.
   b. The shop is easier to clean up.
   c. Fewer accidents occur from falling items and from tripping over equipment in the aisles.
   d. Oil spills do not occur and oily rags do not have to be disposed of.

9. (010) You need a TO for a vacuum tube voltmeter. To find the index for this test equipment, you should use

   a. TO 0-2-1.
   b. TO 0-1-01.
   c. TO 0-4-1.
   d. TO 00-5-1.

10. (011) Directly under the TO number listed in an index will be a letter in parenthesis. This letter indicates

    a. whether the TO is new or revised.
    b. the date of the latest change to the TO.
    c. where the TO is filed.
    d. the security classification of the TO.

11. (013) When a TO deficiency affects safety and the mission of the unit, which of the following improvement reports should you submit?

    a. Emergency.
    b. Record.
    c. Routine.
    d. Urgent.

12. (013) Which type of report should be used to recommend TO improvements for a condition that could be potentially hazardous through prolonged use?

    a. Urgent.
    b. Emergency.
    c. Routine.
    d. Record.

13. (014) Prior to filing a TO change, you should first

    a. annotate title page.
    b. remove replaced pages.
    c. verify dates in master index.
    d. verify completeness against the "A" page.

14. (014) Standard TO binders are labeled by

    a. using AFTO Form 32.
    b. writing directly on the binder cover.
    c. using DD Form 334.
    d. using AFTO Form 110.

15. (014) What symbol will be noted to the left of the TO number on the AFTO Form 110 card to indicate that a TO is on file and current?

a. O.
b. H.
c. +.
d. -.

16. (015) As a supervisor, part of the preparations for receiving a new worker includes

a. assigning the worker tools.
b. inquiring about the worker's housing situation.
c. putting the worker at ease.
d. reviewing the work experience of the new worker.

17. (016) The most important consideration in assigning an individual to a job is the amount of

a. training an individual has had.
b. training an individual needs.
c. time in the career field.
d. time in the Air Force.

18. (017) When making a list of jobs to establish priorities, which of the following is most important initially?

a. Arrangement by importance.
b. Completeness of the list.
c. Inclusion of job deadlines.
d. Inclusion of required materials.

19. (018) Which of the following is the first step in solving a problem?

a. Determine the objective.
b. Get the facts.
c. Take action.
d. Define the problem.

20. (019) Subordinates should be evaluated for all of the following except

a. job knowledge.
b. job proficiency.
c. performance.
d. skill level upgrading.

21. (019) For skill level upgrading, the supervisor should evaluate the trainee's performance against items outlined in the

a. CDC.
b. STS.
c. JPG.
d. APR.

22. (020) Which of the following subjects matches observing, a major step in evaluating a subordinate?

  a. AFM 39-62.
  b. Filling out performance reports.
  c. In comparison with other airmen in same grade and AFS.
  d. Using performance requirements.

23. (021) Under the classification system, utilization is the management of

  a. personnel resources.
  b. materiel resources.
  c. monetary resources.
  d. training resources.

24. (022) In all cases involving mandatory classification actions, who will be a nonvoting member of a classification board?

  a. Training advisor.
  b. Technical advisor.
  c. OJT supervisor.
  d. Section supervisor.

25. (023) What form is used for ordering parts other than bench stock?

  a. AF Form 601B.
  b. AF Form 797.
  c. AF Form 2005.
  d. AF Form 2050.

26. (025) As a supervisor, when coordinating planned maintenance outside your organization you should

  a. consult fellow supervisors.
  b. keep workers informed.
  c. solicit worker's criticisms.
  d. seek the advice of your supervisor.

27. (025) Coordinating planned maintenance results in benefits such as

  a. working together.
  b. increased production.
  c. daily maintenance planning.
  d. arranging resources.

28. (028) As a supervisor, you have control over the most effective use of worker's skills. This factor is most closely related to

  a. money costs.
  b. time.
  c. material.
  d. space.

29. (029) Both the quantity and quality of work performed can be controlled by devices such as

  a. production charts.
  b. a pocket notebook.
  c. performance requirements.
  d. inspecting and checking.

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30. (030) AF Form 1320 is a

a. training chart.
b. task breakdown.
c. maintenance data collection record.
d. combined operation and maintenance planning activity.

31. (031) A responsibility of the immediate supervisor while conducting OJT is to

a. evaluate assigned trainees.
b. instruct trainees on actual equipment.
c. teach theory and background information when required.
d. develop the job proficiency guide.

32. (032) When you relate the job at hand to the work of the whole unit, while acting as a trainer or supervisor, you are

a. preparing the trainee.
b. explaining the operation to the trainee.
c. motivating the trainee.
d. following up the trainee.

33. (034) The feedback postcard received from ECI giving the results of a trainee's volume review exercises is ECI Form

a. 9.
b. 10.
c. 623.
d. 2095.

34. (035) Which of the following would not be a major step in evaluating an OJT training program?

a. Examining training standards.
b. Examining training methods.
c. Assessing program objectives.
d. Assessing program results.

35. (037) What level of maintenance provides technical assistance to the using organization?

a. Depot.
b. Intermediate.
c. Organizational.
d. Maintenance performed by a 7-level worker.

36. (038) MSEP stands for

a. Management System and Equality Program.
b. Management Supervisor and Evaluation Plan.
c. Maintenance Systems and Evaluation Program.
d. Maintenance Standardization and Evaluation Program.

37. (041) Refer to text figure 5-1. Which of the following is not a major staff function in the maintenance complex?

a. Administration.
b. Quality control.
c. Maintenance control.
d. Minuteman missile cable affairs.

38. (042) Deficiency analysis is a subfunction of

a. maintenance supervision.
b. maintenance control.
c. job control.
d. quality control.

39. (042) The function that acts as an extension of the Deputy Commander for Maintenance is

a. quality control.
b. maintenance supervision.
c. maintenance control.
d. training management.

40. (042) Job control is a part of

a. quality control.
b. production analysis.
c. materiel control.
d. maintenance control.

41. (042) The staff function that inspects maintenance actions for evaluation purposes is

a. quality control.
b. maintenance supervision.
c. maintenance control.
d. job control.

42. (043) The staff support function that examines maintenance reports is

a. administration.
b. production analysis.
c. training management.
d. programs and mobility.

43. (043) Which staff support function prepares and submits maintenance reports?

a. Production analysis.
b. Training management.
c. Administration.
d. Programs and mobility.

44. (044) The production control activity responsible for controlling repair cycle assets is

a. DIFM.
b. RPC.
c. RACL.
d. NRTS.

45. (044) Which of the following means "not reparable this station?"

a. DIFM.
b. RPC.
c. RACC.
d. NRTS.

46. (045) Materiel deficiencies that are not in conformance with applicable standards are reported by

a. EUMRs.
b. RUMRs.
c. SF 368.
d. AFTO Form 62.

47. (046) Maintenance that consists of inspecting, cleaning, and lubricating equipment periodically is considered to be

a. preventive.
b. priority.
c. routine.
d. unscheduled.

48. (046) The purpose of a maintenance inspection guide is to provide

a. maintenance schedules.
b. work instructions.
c. an inspection checklist only.
d. work procedures and inspection instructions.

49. (046) Maintenance inspection time intervals may be shortened by the

a. maintenance control officer.
b. Deputy Commander for Maintenance.
c. group commander.
d. wing commander.

50. (055) Which of the following shows the relation of current, voltage and resistance in a DC circuit?

a. $E = \frac{R}{I}$.
b. $R = \frac{I}{E}$.
c. $E = \frac{I}{R}$.
d. $I = \frac{E}{R}$.

51. (056) In a series circuit with four devices, what happens if one of the devices burns out?

a. The remaining three receive a greater portion of the voltage.
b. The voltage drop across each unit remains the same as before.
c. None of the units operates.
d. The three unaffected units continue to operate.

52. (056) The formula for determining equivalent resistance of two parallel resistances is

a. $\frac{R_1 + R_2}{R_1 \times R_2}$.
c. $\frac{2}{R_1 + R_2}$.
b. $\frac{R_1 \times R_2}{R_1 + R_2}$.
d. $\frac{R_1 + R_2}{2}$.

53. (056) When solving for current or resistance in series-parallel circuits, the

a. parallel legs should be computed first.
b. series leg should be computed first.
c. computation of both legs are made simultaneously.
d. computation can be made in any order.

54. (057) What are the two main characteristics of alternating current?

a. Constant amplitude and periodic change in direction.
b. Periodic amplitude and unidirectional flow.
c. Varying amplitude and periodic reversal of direction.
d. Bidirectional amplitude and periodic flow.

55. (057) Which of the following terms indicates the number of cycles of AC that occurs in one second?

a. Frequency.
c. RMS value.
b. Amplitude.
d. Reversals.

56. (058) Requirements for generating a self-induced voltage are

a. coil, core, and relative motion.
b. conductor, magnetic field, and relative motion.
c. electromagnetic, conductor, and sliprings.
d. magnetic field, sliprings, and relative motion.

57. (058) The symbol X_L placed by a component in a circuit schematic represents

a. inductor resistance.
c. inductive reactance.
b. capacitor resistance.
d. capacitive reactance.

58. (059) The amount of electricity a capacitor can store depends on its

a. dielectric, the difference of the plates, and the voltage applied.
b. plate area, distance between the plates, and the dielectric.
c. dielectric, voltage applied, and frequency.
d. plate area, dielectric, and the frequency.

59. (059) As the frequency applied to series capacitors is increased, the

a. current will decrease.
b. current will increase.
c. total reactance will increase.
d. total capacitance will increase.

60. (059) As the frequency increases in a series RC circuit,

a. capacitance increases.
b. capacitance decreases.
c. capacitive reactance increases.
d. capacitive reactance decreases.

61. (060) A full-wave solid state rectifier circuit requires

a. two diodes.
b. load resistance.
c. center tapped transformer.
d. all of the above.

62. (060) If 60 Hz AC is applied to a PN junction, the resulting current will be

a. pure DC.
b. 60 pulses per second.
c. 120 pulses per second.
d. 60 Hz AC.

63. (060) How may the output polarity of the full-wave solid state rectifier be reversed?

a. Reverse the transformer secondary leads.
b. Ground the secondary center tags.
c. Reverse the load resistance.
d. Reverse the diodes.

64. (061) In an operating transistor, approximately how much of the emitter current reaches the collector?

a. 100 percent.
b. 95 percent.
c. 50 percent.
d. 5 percent.

65. (061) Whch element of a triode junction transistor is represented by an arrow?

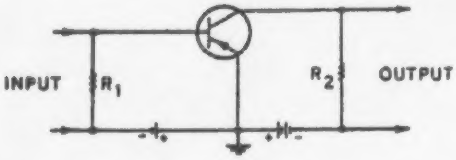
a. Emitter.
b. Base.
c. Collector.
d. Case.

66. (061) Which of the following is the normal way to bias a transistor?

a. Emitter-base forward, base-collector forward.
b. Emitter-base reverse, base-collector forward.
c. Emitter-base forward, base-collector reverse.
d. Emitter-base reverse, base-collector reverse.

67. (061) The transistor amplifier circuit shown below is

a. an NPN common base.
b. a PNP common base.
c. an NPN common emitter.
d. a PNP common emitter.



68. (062) In a common emitter amplifier circuit, there is

a. power gain of one.
b. voltage gain less than one.
c. high input and output resistances.
d. phase reversal between input and output.

69. (064) The test lamp is constructed as a

a. parallel circuit.
b. series-parallel circuit.
c. series circuit.
d. resonant circuit.

70. (064) On some test receivers, the test probe comes equipped with a removable

a. series resistance.
b. series capacitance.
c. parallel resistance.
d. parallel capacitance.

71. (065) Which statement best describes the purpose of a central office test desk?

a. Used for testing cable pairs and subscriber's end equipment.
b. Used for testing all circuits passing through the central office MDF.
c. Used for line and equipment tests from a central location.
d. Used for testing all switchboard circuits and cable pairs.

72. (066) With all lever switches in their normal or nonoperated position, what is the maximum voltage range of the type 1 test desk multimeter?

a. 0 to 150 volts.
b. 0 to 300 volts.
c. 0 to 450 volts.
d. 0 to 600 volts.

73. (066) The installer repairman calls into the type 1 test desk for line checks through the

a. test desk trunk.
b. test trunk to MDF.
c. In-call circuit.
d. Out-call circuit.

74. (067) Operating the MDF OUT switch permits testing, through the test shoe and protector, a

a. cable pair, by-passing the heat coils.
b. cable pair, going through the heat coils.
c. cable pair in series with the carbon block.
d. cable pair or jumper, by-passing the heat coils.

75. (067) An installer repairman gains access to the type D test desk for line tests by means of a

a. selector level trunk.
b. test selector trunk.
c. test distributor trunk.
d. test connector trunk.

76. (068) The line insulation routiner tests for line insulation faults that are

a. below preselected maximum sensitivity values.
b. above preselected maximum sensitivity values.
c. below preselected minimum sensitivity values.
d. above preselected minimum sensitivity values.

77. (068) On the insulation routiner test panel, operating the PRESET lever switch of the line isolation seizes what central office equipment?

a. Test connector.
b. Test distributor.
c. Selector level trunk.
d. Special second selector.

78. (069) The automatic equipment routiner has a capability of testing how many different test groups?

a. 3.
b. 4.
c. 5.
d. 6.

79. (070) How many digits does the printout tape of the line insulation routiner contain?

a. 6.
b. 7.
c. 8.
d. 9.

80. (070) The last digit of the line insulation routiner printout is a code for the

a. fault.
b. central office.
c. test sensitivity.
d. connector hundreds group.

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CDC 36251

TELEPHONE SWITCHING EQUIPMENT REPAIRMAN (ELECTROMECHANICAL)

(AFSC 36251)

Volume 2

Telephone Fundamentals and Manual Telephone System

Extension Course Institute

Air University

Preface

FUNDAMENTAL KNOWLEDGES are essential, as a foundation in any field of study or endeavor. The peculiar thing is that people, after attaining their goal, tend to forget the importance of that foundation.

In the business of providing telephone service, fundamentals stare us in the face almost daily. Most of the maintenance actions taken each day deal with relays and switches.

This second volume presents material about relays and switches. It also contains an overview of basic telephone principles as well as installation fundamentals and familiarization on the operation and maintenance of the AN/FTA-13 manual telephone system.

Bound as a separate supplement to this volume are seven foldouts. Whenever you are referred to these foldouts in the text, please turn to the supplement and locate the one called for.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to SAAS/TTOXU, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behaviorial Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 33 hours (11 points).

Material in this volume is technically accurate, adequate, and current as of December 1978.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Telephone Systems Relays

RELAYS DO IT ALL! Think about it for a minute. Can you think of anything in the central office circuitry that works without at least one? The funny thing is, we don't think about relays in our day-to-day business of providing telephone service. We tend to concern ourselves with linefinders, selectors, connectors, repeaters, etc. Why? The reason is simple; relays are reliable! Why? Again, the reason is clear; you! Me? You bet; your skill in properly adjusting relays along with well manufactured relays are the reasons that relays are reliable.

In this chapter we deal with the two types that we spend 99 percent of our time on. The first section is about the Automatic Electric relays that we find in our Strowger step-by-step exchanges. The second section deals with the Stromberg-Carlson relays found in the XY exchanges and in the AN/FTA-13 manual telephone system.

In each section we discuss relay components, interpretation of relay adjustment specifications, use of adjustment tools and test equipment, and how the various adjustments affect other adjustments.

Relays operate in a specific way because of current variations. Most relays operate on a specific minimum value of current. The current required is determined by the construction of the relay—for example, each spring is tensioned; therefore, several springs placed together on a relay provide a load that is an accumulation of the tension of the individual springs. Thus, if the three springs of an assembly (also called a pileup) each have 5 grams' tension, the spring load against the associated armature is 15 grams. The current in the relay must be sufficient, then, to develop a magnetic field which is strong enough to pull the armature that has this 15 grams' load. Remember that we speak of a relay as being operated when the current in the windings is of sufficient value to cause the armature to move toward the core. To be fully operated, however, the armature must move sufficiently from its unoperated position to close all of its normally open contacts and to open all of its normally closed contacts. Relay types are identified by their action. A marginal relay or quick-acting relay pulls its armature to the core immediately after the relay's operating circuit is completed and permits the armature to restore without any delay after the operating circuit is opened. This marginal relay operates when the current in its windings reaches a specified operate value. It remains operated, also, while the current decreases to another specified level. At this time, when the current has decreased to the release value, the relay armature restores. The time difference, lag, between the disconnect of the relay's operating circuit and actual armature release is so slight that it is hardly noticeable. In certain cases, a relay may need a definite time delay for either its operations or release. The coil-and-core construction usually provides this time-delay feature.

1-1. Automatic Electric Relays

Automatic Electric relays are an integral part of the Strowger Central Office. Considering all the offices maintained by the Air Force, we know that there are thousands of combinations of relay coils, contact springs, and mountings used in thousands of circuits. Fortunately for the student and the test man, all relays are based on the same general principles.

A relay can be constructed to operate at fast or slow speeds while moving two or more contact springs, and it can be placed in a position which is readily accessible to the repairman. It can be mounted with the contact springs resting on a horizontal plane, with reference to its mounting plate. In this position, the contact springs offer more area for dust to collect. This type of mounting probably permits some gravitational assistance to the armature movement. The contact spring banks in the assembly appear as left and right banks for

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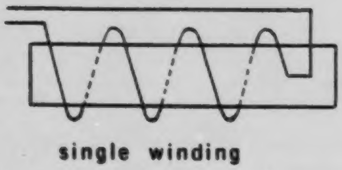


Figure 1-1. Single-wound relay.

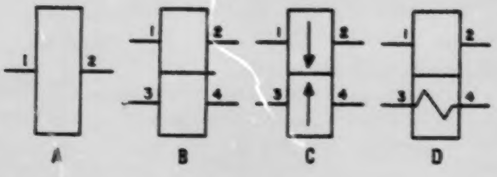
the horizontally mounted relay. Vertical mounting of the relay permits the contact springs to rest with their thinnest edge, facing the top of the equipment frame; thus they offer less area for dust collection. The contact banks in the vertical mounted assembly are identified as top bank and bottom bank of contacts.

200. Given a picture of an Automatic Electric relay, identify selected components and state the function of each.

A relay includes four major parts: the frame, the coil, the armature, and the spring assembly.

Frame. The frame supports the other components and offers little opposition to the mechanical movement of the armature and springs. Also, it is constructed of a metallic material, such as soft iron or silicon steel to insure reliable relay operation. This metallic material allows a magnetic field easy passage. Therefore, following a rapid field expansion, the relay returns to a normal, nonmagnetic condition rapidly after the electrical surge has been terminated. A frame (also referred to as heelpiece or heel iron) may be constructed to support one or more relays.

Coil. The coil consists of many turns of fine wire wound upon a core made of a material that is easily magnetized. Each turn is insulated from the other by an enamel coating. The successive layers of the winding are usually separated by layers of thin insulating paper. The completed coil is covered by insulation. Each relay, as a result of this construction, is less likely to be affected by moisture. A fiber disc at each end of the coil holds the wire in place. A lead-out wire from each end of the coil connects to terminals, thus becoming attachment points for the power source. There are several different methods of placing the wire on the core. The method used depends on the particular function which the relay serves. We present information about these developmental procedures, since you may understand the relay's operation better if you have some knowledge of the coil's development.



A. SINGLE-WOUND COIL, FAST ACTING
B. COIL WITH TWO WINDINGS
C. DIFFERENTIAL TANDEM-WOUND COIL
D. CONCENTRIC-WOUND COIL WITH NON-INDUCTIVE WINDING

Figure 1-2. Relay symbols for telephone circuits.

The single-wound coil has one winding as illustrated in figure 1-1. On a schematic, they are often represented as shown in figure 1-2,A. This type of coil is most often used with fast-operating relays. The range of operating time can vary from about 8 to 30 milliseconds. This, of course, will depend upon the way the relay is used, the amount of current in the circuit, the turns in the coil, the number of contacts in the stack or stacks and their gap settings, the type and setting of residual—all of these affect the operation of a relay. The exact combination must be carefully engineered into the unit to meet the requirements.

Single-wound coils are also used to produce slow-acting relays of three general types: slow-acting, slow-operating, and slow-releasing. Figure 1-3 shows a method of representing these relays on a schematic. The relay operating time delay ranges from 35 to 200 milliseconds. The operating time is determined by the circuit opposition, the power input, the number of contacts, the spring tension, etc. A procedure useful in delaying the operating time of a relay has been developed by engineers. They place a copper sleeve over the core of the relay (fig.1-4) to make the relay slow acting (slow to operate and slow to release). The copper sleeve acts as a huge turn of a secondary winding which, as the current is building up in the magnet coil, opposes the concentration of the magnetic field in the core for a short time (until the current has reached a maximum). When the circuit is opened and the

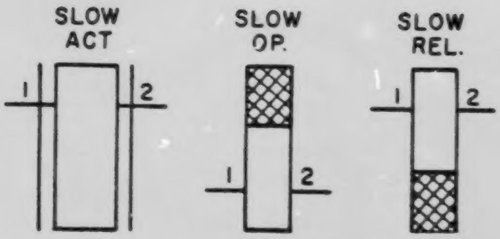


Figure 1-3. Slow-acting single-wound relay symbols.

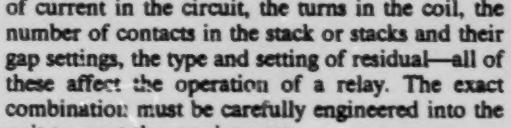


Figure 1-4. Magnetic field response at relay with copper sleeve.

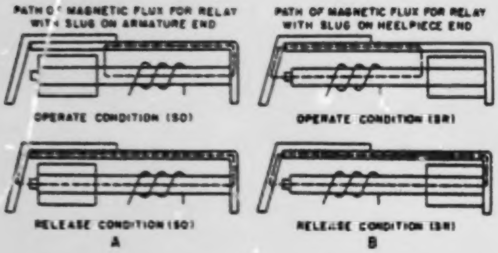

PATH OF MAGNETIC FLUX FOR RELAY WITH SLUG ON ARMATURE END
PATH OF MAGNETIC FLUX FOR RELAY WITH SLUG ON HEELPIECE END
OPERATE CONDITION (SO)
OPERATE CONDITION (SR)
RELEASE CONDITION (SO)
A
RELEASE CONDITION (SR)
B

Figure 1-5. Copper slug effect on telephone relays.

magnetic field is collapsing, the voltage induced into the copper sleeve opposes the change in the field and tends to keep the field strength at the previous level. The delay in the release of the relay, as a result of this field induction, may range up to 250 milliseconds. A relay with a sleeve-encased core operates more quickly than it releases.

A copper slug placed at either end of the core also causes a delay in the relay's operating and releasing time. Figure 1-5,A, can help explain the operation of a coil with a single winding used as a slow-to-operate relay. A copper slug placed at the armature end of the core develops an opposition to the expansion of the magnetic field, thus restricting armature movement temporarily. When the magnetic field reaches its maximum level of strength, the opposition diminishes and sufficient force is then available at the armature end of the core to attract the armature. The size of the slug, number of turns in the coil, amount of current, number, and resistive force of the contact springs—all of these affect the operating time of this relay. These relays can be adjusted to operate after 35 to 200 milliseconds. Release time is also delayed by the action of the slug, ranging from 50 to 170 milliseconds.

Slow-to-release relays are built with the slug at the heel end of the coil, where opposition to the magnetic flux field is slight when the relay is operating (see fig. 1-5,B). Operate time can be engineered to vary between 10 to 95 milliseconds. The heel-end slug has a greater effect on the relay's release. It can be designed to delay the collapse of the magnetic field for from 25 to 250 milliseconds.

Many of the relays found in our equipment have two coils wound on the same core. A tandem-wound coil consists of two (half-length) windings placed end to end. The heel end is known as the first winding and is connected to terminals 1 and 2. The armature end or second winding is connected to terminals 2 and 4 when it is desirable for the coil to be operated from either winding. Tandem coils have been symbolized on circuit drawings, as shown in figure 1-2,B. A tandem coil can be used for operating a relay using differential principles. For this purpose, the battery is connected to terminals 1 and 4; thus, the two windings create magnetic fields that oppose. Illustration C of figure 1-2 has been used to identify this type of relay in schematic diagrams, and figure 1-6 presents a view of the wiring procedure.

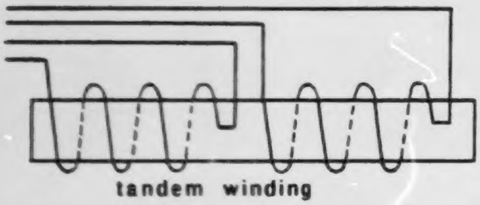


Figure 1-6. Telephone relay with tandem windings.

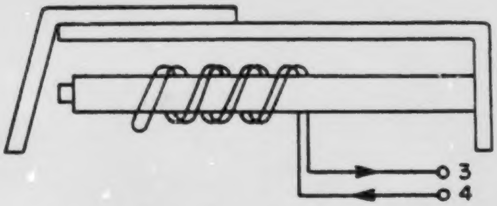


Figure 1-7. Noninductive winding for telephone relay.

Concentric-wound coils consist of two windings wound one over the other. This relay has also been referred to as double-wound. The inside winding is connected to terminals 1 and 2. The outside, or second winding, is connected to terminals 3 and 4. Normally, a concentric-wound relay is represented on a schematic by a symbol similar to that used for a tandem relay. In some instances, a concentric-wound relay is represented by a symbol as shown in figure 1-2,D. This additional winding indicates that it is a special construction. It is wound to produce no magnetic effect. To achieve this, the wire is doubled back as shown in figure 1-7, looped, and then connected to terminals 3 and 4. The magnetic fields created by the current in the loops are in opposition. In effect, then, they cancel. Nickel-silver wire, which has a high resistance, is generally used, since fewer turns are needed than when copper wire is used. This type of winding is used primarily in a circuit that needs high opposition to limit the direct current, yet needs low opposition to low-frequency voice currents. You may see a circuit where the noninductive winding is used to suppress sparks which are developed at relay contacts.

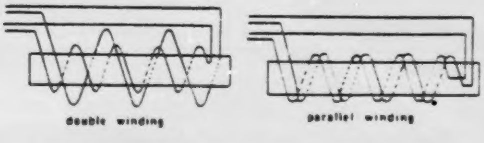


Figure 1-8. Multiple windings for telephone relay.

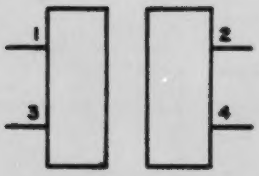


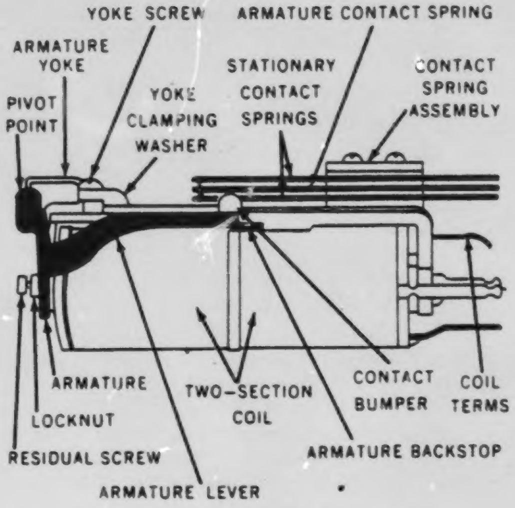
Figure 1-9. Multiple-wound coils symbol.

Relays that have the windings wound in parallel are used primarily in telephone transmission circuits. The two windings are wound side by side, simultaneously forming two independent coils which are identical in respect to number of turns, resistance, and inductance. B of figure 1-2 also symbolizes this type of relay in telephone schematic diagrams. Figure 1-8 illustrates the difference in looping procedure with concentric and parallel-wound coils.

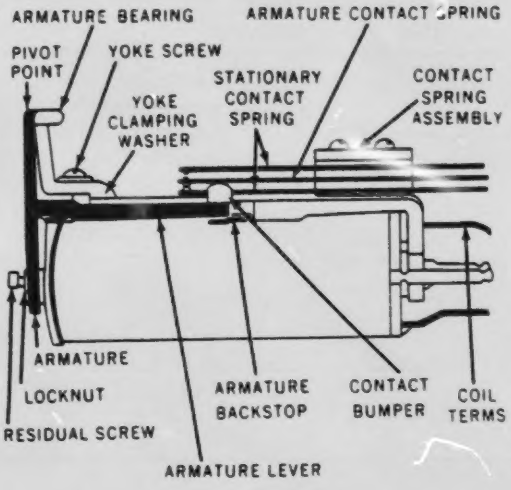
The core of a multiple-wound relay is U-shaped and each leg has a single winding. The winding of one leg terminates at terminals 1 and 3, whereas the winding of the other leg attaches at terminals 2 and 4. Figure 1-9 shows the symbol for this type of relay. A multiple-wound relay has had limited use because of the unique construction. It is used only in special circuits.

Armature. The metallic armature pivots on the frame and is attracted toward the core which is magnetized by the current in the coil. This armature is constructed of soft iron, to lessen the possibility of its retaining a magnetic force after the current in the coil has been reduced; or it is constructed of silicon steel, which operates on a small energy input. A permalloy armature permits a relay to be fast-operating. Each armature usually has a protective finish of zinc, nickel, or chromium. A pin secures the armature to a retainer, yoke, or mounting plate and serves as a bearing which gives the armature more freedom in movement. This pin is durable and allows a minimum of side-play. The mounting device is attached to the frame with one or more screws. Because of this construction, it is possible to make some adjustments in the space between the armature and frame. Armatures are of several types. Some may be mounted at either end of the core.

Figure 1-10 illustrates a standard-lever armature and a short-lever armature. As you can see in figure 1-10,A, the standard-lever armature has a ratio of approximately 2.75 to 1; that is the lever (measured from the armature to the contact bumper) is approximately 2.75 times as long as the armature (measured from the pivot point to the residual screw). This gives the contact springs a mechanical advantage of approximately 2.75 to 1 in respect to the armature. Thus, the contact springs on a relay with a standard-lever armature will release very quickly. For this reason, the standard-lever armature is used on fast-operating relays. As you can see in figure 1-10,B, the short-lever armature has a ratio of approximately 1 to 1. In this case, the length of the lever (measured from the armature to the contact bumper) is approximately equal to the length of the armature (measured from the pivot point to the residual screw). With a 1-to-1 ratio, the contact springs are unable to restore the armature until the magnetic field has died down to a low value. Thus, the contact springs on a relay with a short-lever armature will release rather slowly. For



A. STANDARD LEVER ARMATURE



B. SHORT LEVER ARMATURE

Figure 1-10. Telephone relay armatures.

this reason, the short-lever armature is used with slow-acting relays.

The armature's movement is limited by the strength of the magnetic field, the resistance of the operating circuit, the current in the coil, and the load of the spring assemblies. The interrelationship of the first three of these four controlling features is close, as you know from studying the fundamentals of electricity. You should remember that the current of any circuit is determined by the opposition; a large resistance results in a small current, and more current is indicative of less resistance within a circuit. At the same time, an increase in current through a relay coil results in a stronger magnetic field; and this field, in turn, causes the armature to be attracted more forcefully. Relay armatures will have some residual magnetism after the energizing force is removed. Therefore, to keep the armature from touching and sticking to the coil's core, a nonmagnetic residual plate is attached to the armature. Some relays have a small setscrew to adjust the gap (separation) between the armature and core. This brass residual screw passes through the armature at the point directly opposite the center of the core. Following adjustment, the screw is locked in place with a locknut. Changing the gap changes the relay release time. This residual screw allows for quick adjustment, but the adjustment should never be made without serious consideration of its consequences and without knowing if the adjustment is really necessary.

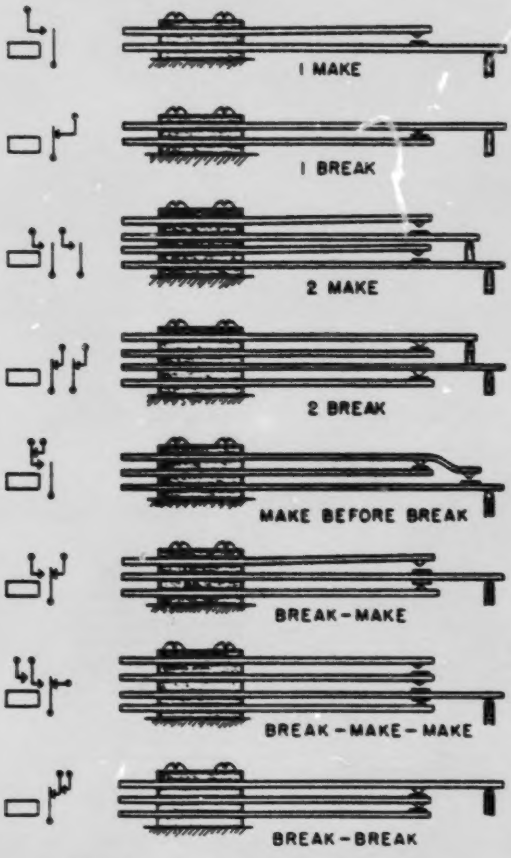


Figure 1-11. Arrangement of relay contact springs.

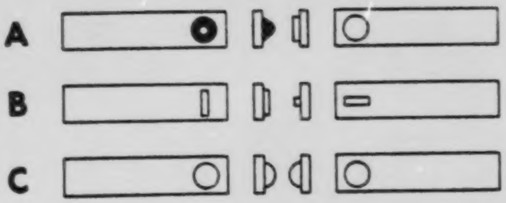


Figure 1-12. Types of contacts for telephone relays.

> NOTE: If the residual screw were turned in too far, the armature movement would be insufficient to force the contact bumper or pushers an adequate distance to make or break all contacts. A residual screw that extends too far out may not keep the armature from sticking; thus the relay's release would be impossible.

We can see that residuals differ in design and construction, but regardless of their development they all do the same thing. They prevent the armature from remaining against the core after the current is removed from the circuit.

Spring Assembly. Associated with the armature are one or more contact springs. You should realize, too, that the movement of the armature must be sufficient to overcome the opposition of the springs within the spring pileup. The springs are usually of nickel-silver composition, which provides adequate spring tension to permit the required action. The function of these springs is like that of a switch. When they are forced to move, they close or open electrical circuits. Each spring is insulated from the other by means of a fiber spacer, and in order to control the contact effectiveness, the armature must move the springs into the desired position. The springs are arranged to form four basic types of spring combinations:

- Make.
- Break.
- Break-make.
- Make-before-break.

Figure 1-11 depicts spring combinations. The term "make" refers to a pair of contacts whose switching action closes (completes) the controlled circuit when the relay is operated; hence these contacts are called normally open contacts. The term "break" refers to a pair of contacts that are normally touching; the operated relay opens them; therefore, the circuit being controlled is incomplete. The break-make operation opens one

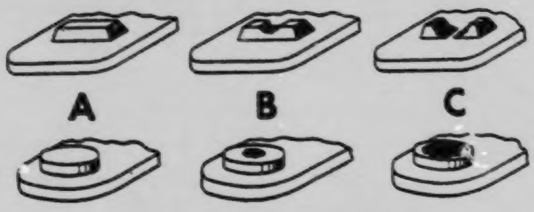


Figure 1-13. Progressive wear of relay contacts.

controlled circuit, while simultaneously completing another controlled circuit. The make-before-break arrangement is sequential action; one controlled circuit must be completed before an associate circuit can be opened. This latter action is very necessary in the dial telephone equipment circuits, since a telephone call could not progress without it. Example: the succeeding equipment, a connector for instance, must return a potential to the preceding equipment (selector) if the call is to be completed. This action is done by a relay which is constructed with make-before-break contacts in the spring assembly.

In some combinations, the spring is forced to continue moving for a short time after the contacts touch, as the contacts meet, the armature forces the traveling spring (swinger) to travel a little further, placing a bow in the stationary spring. From this mating of the contacts and with the accompanying contact "follow," the contacts rub together to provide a self-cleaning effect. This action insures good electrical contact.

The contacts on the springs of the assembly are made of gold, silver, tungsten, silver alloys, or alloys of platinum, and quite often are plated with cadmium or nickel. This construction makes them more durable under the conditions where they operate. When contacts either complete or open a circuit, there is likely to be sparking. This is especially true in a circuit which includes only a relay. The voltage at the relay contacts of such a low resistance circuit at the time of closure may be negligible when compared to the voltage that could be observed when the contacts open. Two reasons for this sparking effect are these: (1) contact separation begins slowly and (2) the speed of contact movement increases as the contacts get farther apart. Also, the collapsing magnetic field of the core and coil induces a voltage, in an effort to keep current in the relay operating circuit. The result of these conditions is that the contacts get burned or they vaporize. Pits or buildups do not necessarily mean that the life of the contact is ended. The contacts are formed as discs, bars, or points and are attached to the springs by spotwelding. Figure 1-12,A, illustrates the pointed contact; its mate, 1-12,B, shows the bar-shaped (also referred to as crosspoint) contacts; and 1-12,C, pictures the disc contacts.

The size and shape of contacts depend largely upon the mechanical wear to which they are subjected and upon the energy to be controlled. In cases of severe operating conditions, the contacts are made large enough to take care of manufacturing variations in location as well as contact alignment. For example, a point contact may be mated with a disc contact, or two bar contacts may be mated. In most cases, the useful life of a relay is determined by the life of its contacts. The contact material must be free from corrosion, as corrosion acts like a high-resistance film on the contact surface. Contacts must also be able to withstand the electrical wear caused by arcing and must be sufficiently hard to limit the wearing away to a minimum. Contact protection (spark suppression) circuits are used to prolong the life of contacts. Figure 1-13,A, pictures normal bar and disc relay contacts; 1-13,B, reveals pits that have developed as a result of arcing; and 1-13,C, shows contacts that are in need of replacement. These latter contacts have been vaporized until the metal of the springs can be seen. Figure 1-14 illustrates contact pitting and the associated buildups. B of figure 1-14 shows a buildup with a sharp point; this type of defect has resulted in a mechanical locking action following the closing of the contacts. Many relays are constructed with twin contacts, a contact on each arm of a Y-shaped contact spring; thus each contact acts independently. If one arm and its associate contacts fail to function because of grit, corrosion, etc., the other contact can complete the operation. Twin contacts also can provide a higher current carrying capacity than can a single contact.

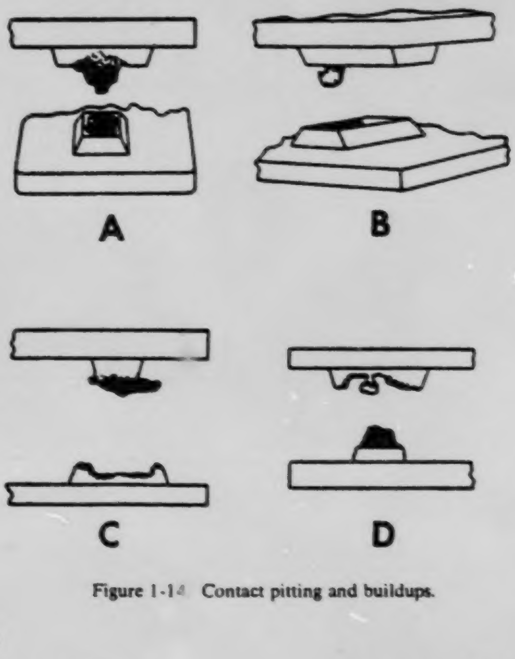
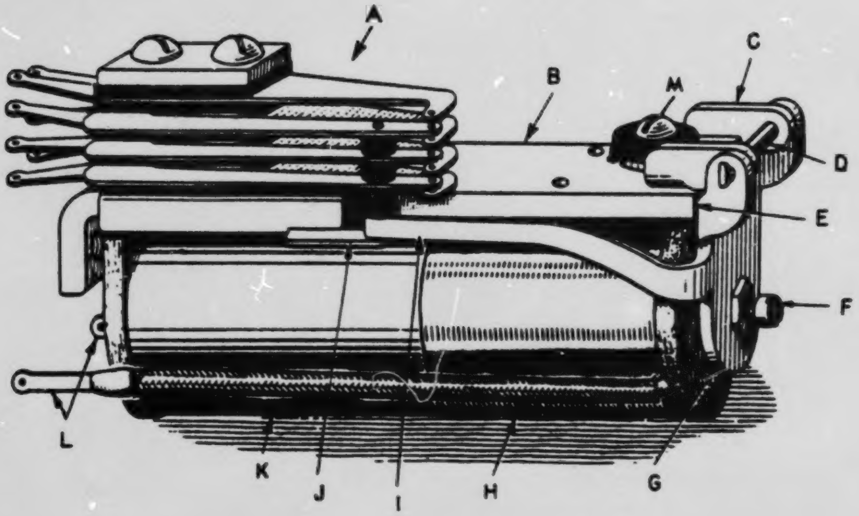


Figure 1-14 Contact pitting and buildups.

Contacts and springs are usually given an identical number. Spring numbering is necessary because without it the repairman or any other interested person would find it inconvenient to identify the specific device which he seeks.

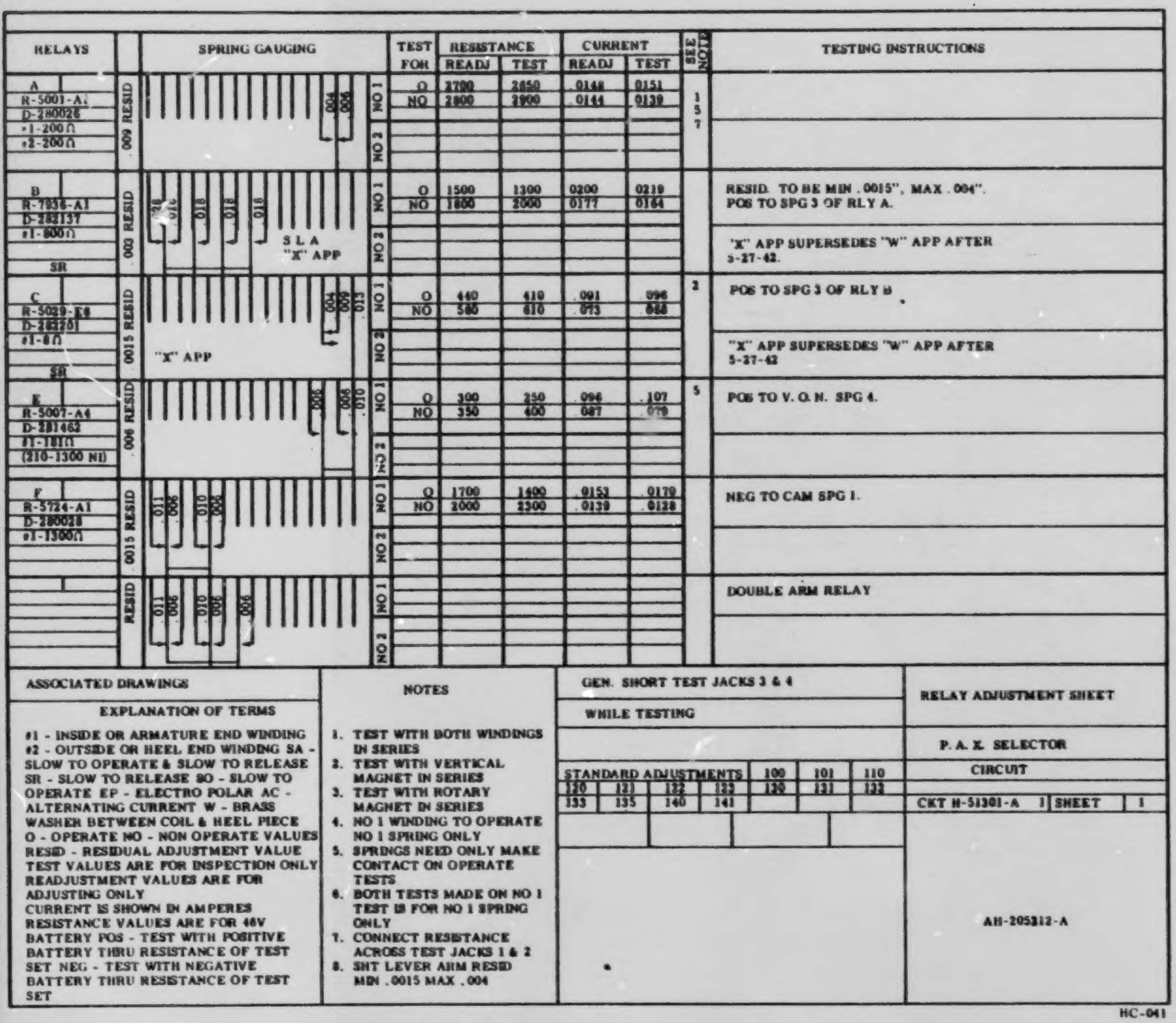
Exercise (200):

1. Indentify the parts in figure 1-15 marked with lettered callouts in the space provided and state the function of each.



A. Spring Assembly
B. Heelpiece
C. Armature Yoke
D. Pivot Pin
E. Airline or Air Gap
F. Residual Screw
G. Armature
H. Coil
I. Armature Lever Arm
J. Armature Arm Backstop
K. Copper Slug
L. Terminals
M. Armature Yoke Screw

Figure 1-15. Strowger horizontal-type relay (objective 200, exercise 1).



RELAYS		SPRING GAUGING		TEST FOR	RESISTANCE READJ	RESISTANCE TEST	CURRENT READJ	CURRENT TEST	SEE NOTE	TESTING INSTRUCTIONS
A R-5001-A1 D-280026 #1-200Ω #2-200Ω	.009 RESID	.004 .006	NO 1	O NO	2700 2800	2650 2900	.0148 .0144	.0151 .0139	1 5 7	
			NO 2							
B R-7036-A1 D-282137 #1-800Ω SR	.003 RESID	.026 .016 .018 .018 .016 S L A "X" APP	NO 1	O NO	1500 1800	1300 2000	.0200 .0177	.0219 .0164		RESID. TO BE MIN .0015", MAX .004". POS TO SPG 3 OF RLY A.
			NO 2							"X" APP SUPERSEDES "W" APP AFTER 5-27-42.
C R-5029-E6 D-282201 #1-8Ω SR	.0015 RESID	.004 .009 .013 "X" APP	NO 1	O NO	440 580	410 610	.091 .073	.096 .068	2	POS TO SPG 3 OF RLY B
			NO 2							"X" APP SUPERSEDES "W" APP AFTER 5-27-42
E R-5007-A4 D-281462 #1-181Ω (210-1300 NI)	.006 RESID	.006 .006 .010	NO 1	O NO	300 350	250 400	.096 .087	.107 .079	5	POS TO V. O. N. SPG 4.
			NO 2							
F R-5724-A1 D-280028 #1-1300Ω	.0015 RESID	.011 .006 .010 .006	NO 1	O NO	1700 2000	1400 2300	.0153 .0139	.0179 .0128		NEG TO CAM SPG 1.
			NO 2							
	RESID	.011 .006 .010 .006 .006	NO 1							DOUBLE ARM RELAY
			NO 2							

ASSOCIATED DRAWINGS

EXPLANATION OF TERMS

#1 - INSIDE OR ARMATURE END WINDING
#2 - OUTSIDE OR HEEL END WINDING SA - SLOW TO OPERATE & SLOW TO RELEASE SR - SLOW TO RELEASE SO - SLOW TO OPERATE EP - ELECTRO POLAR AC - ALTERNATING CURRENT W - BRASS WASHER BETWEEN COIL & HEEL PIECE
O - OPERATE NO - NON OPERATE VALUES
RESID - RESIDUAL ADJUSTMENT VALUE
TEST VALUES ARE FOR INSPECTION ONLY
READJUSTMENT VALUES ARE FOR ADJUSTING ONLY
CURRENT IS SHOWN IN AMPERES
RESISTANCE VALUES ARE FOR 48V BATTERY POS - TEST WITH POSITIVE BATTERY THRU RESISTANCE OF TEST SET NEG - TEST WITH NEGATIVE BATTERY THRU RESISTANCE OF TEST SET

NOTES

1. TEST WITH BOTH WINDINGS IN SERIES
2. TEST WITH VERTICAL MAGNET IN SERIES
3. TEST WITH ROTARY MAGNET IN SERIES
4. NO 1 WINDING TO OPERATE NO 1 SPRING ONLY
5. SPRINGS NEED ONLY MAKE CONTACT ON OPERATE TESTS
6. BOTH TESTS MADE ON NO 1 TEST IS FOR NO 1 SPRING ONLY
7. CONNECT RESISTANCE ACROSS TEST JACKS 1 & 2
8. SHT LEVER ARM RESID MIN .0015 MAX .004

GEN. SHORT TEST JACKS 3 & 4

WHILE TESTING

STANDARD ADJUSTMENTS				100	101	110
120	121	122	123	130	131	132
133	135	140	141			

RELAY ADJUSTMENT SHEET

P. A. X. SELECTOR

CIRCUIT

CKT H-51301-A 1 | SHEET 1

AH-205312-A

HC-041

Figure 1-16. Automatic electric relay adjustment sheet.

201. Given a relay adjustment sheet, interpret selected portions of it.

The relays installed in telephone equipment are not often checked individually because they are a part of a circuit. Testing the circuit reveals the condition of its components. For instance, if the tests performed on a given circuit reveal no symptoms of trouble, it is safe to assume that all components of the circuit are meeting their requirements. Of course, there are many relays and components used in some circuits and any one of them could cause the circuit to fail. One advantage of using relays in telephone equipment, however, is that the relay armatures are practically the only moving parts within the equipment. These armatures move only a few thousandths of an inch; and, in so doing, they make or break the associated contacts. Circuits are affected by the actuated contacts. Particles of dust between these contacts can limit or prevent the operation of such circuits.

Actual practice has shown us that a minimum of maintenance is required with relays when care is exerted in keeping the telephone equipment area clean. Relays hold their adjustment for long periods of time and, if left undisturbed, require little maintenance. There is a gradual deterioration, but manufacturers are aware of this and make allowances for it. There are only two cases when you may find it necessary to do any relay adjustment. The first situation occurs when equipment fails to work properly, and the second exists when tests reveal that there is a discrepancy in the relay adjustment value. Relays can be adjusted, but not repaired, while installed on the equipment. You can change the armature travel, spring alignment, and contact spacing; but if the relay has a broken spring or grounded coil, you must replace the assembly.

Before we mention relay adjustments, a few words of caution are in order. You should never touch relay adjustments unless tests indicate that it is necessary to do so. You must use extreme care when working on telephone equipment, because tools dragging on, or unintentionally hitting a relay, may knock it out of adjustment. The failure of such a relay may disrupt one or more circuits in the telephone system or equipment.

Relay adjustment is divided into two major classifications: electrical and mechanical. Electrical adjustment consists of applying specified amounts of current to the relay while observing its operation. The values of these currents are similar to those applied to the relay under actual operating conditions. The mechanical adjustments consist of gauging and tensioning of springs, spacing and aligning of contacts, and aligning the mechanical parts of the relay. Actually, the mechanical adjustments are performed to cause the relay to function on its specified current values.

Relay Adjustment Sheet. The relay adjustment sheet, figure 1-16, contains a wealth of information; but you have to be able to understand the information in order for it to do you any good. The adjustment sheet has four (4) major columns plus NOTES and EXPLANATION OF TERMS blocks. The major columns are RELAYS, SPRING GAUGING, TEST FOR, and TESTING INSTRUCTIONS.

For each circuit, connector, repeater, etc., there is a sheet or series of sheets that make up the relay adjustment sheet. We start at the left side of a typical adjustment sheet and move to the right.

Relays. This column lists the relays that make up the circuit you are working on. Under the relay designation you find an R number. This is the number of the heelpiece assembly. Below the R number is a D number. The D number is the number of the coil that is used for this relay. The No. 1 and No. 2 (if the relay has two windings) and the ohmic values that follow them indicate the resistance of the individual windings of the coil listed. To the right of the relays information, between this and the next column, is the residual screw setting shown in thousandths of an inch.

Spring gauging. In this column you find a drawing of the relay contacts for a particular relay (fig. 1-16). Notice that the contacts for relay A, C, and E are shown on the right-hand side of the column; while the B and F relay contacts are shown on the left. This indicates what side of the assembly the spring contacts are located. The A, C, and E relay contacts are numbered from the center (coil) to the left (outside) as you look at the assembly, whereas the B and F relay contacts are numbered from the center of the assembly to the right (outside) of the assembly.

The contacts shown for relay A in figure 1-16 indicate that with a .006 inch gauge placed between the residual screw and the core, contacts 1 and 2 break. For practical purposes you use .005 and .007 inch gauges to check this adjustment. With a .007 gauge inserted contacts 1 and 2 don't break; with a .005 inch gauge inserted they do. It works that way because the .005 inch gauge allows the armature to travel further.

For contacts 2 and 3, which are make contacts, a .005 inch gauge inserted between the residual screw and the coil does not allow them to make. By inserting a .003 inch gauge contacts 2 and 3 should make.

Take a look at the spring gauging column for relays C and E; to the right of the contacts and their adjustment specifications is a minicolumn with a three-place number. This number indicates in thousandths of an inch the stroke requirement for that relay. The stroke is the distance between the tip of the armature residual screw and the coil core, when the armature is at normal. This column sometimes contains notes indicating SLA (short lever armature) or "X" APP (X application, which refer to a specific issue drawing for this circuit).

Test for. This major column has six subcolumns. Under the words TEST FOR you find an O and an NO line. O stands for Operate and NO for Nonoperate and is explained in the Explanation of Terms block at the bottom of the sheet. To the right you have two subcolumns of resistance specifications and two subcolumns of current specifications. The resistance and the current specifications subcolumns are for use in setting up your current flow test set. If your current flow test set is the resistance type, you use the resistance specifications. If it is a current type, the I-181 for instance, you use the current specifications. The values shown in the test columns are used only when determining if a relay is out of adjustment. When a relay is to be adjusted the values shown in the Readj column are used as they are more stringent than the values found in the Test column. In the SEE NOTE subcolumn are numbers referring you to, when applicable, the notes block at the bottom of the adjustment sheet.

Testing instructions. Contained in this column are special notes necessary to the proper testing and adjusting of a specific relay.

Exercises (201):

Use figure 1-16 to provide answers for the following questions about interpreting relay adjustment sheets.

1. What is the resistance of the No. 1 winding of relay F?

2. What is the residual screw adjustment for the B relay?

3. What is the Operate and Nonoperate test values, both resistance and current, for relay C?

4. What size gauge, inserted between the residual screw and coil core, should cause contacts 4 and 5 of relay B to make?

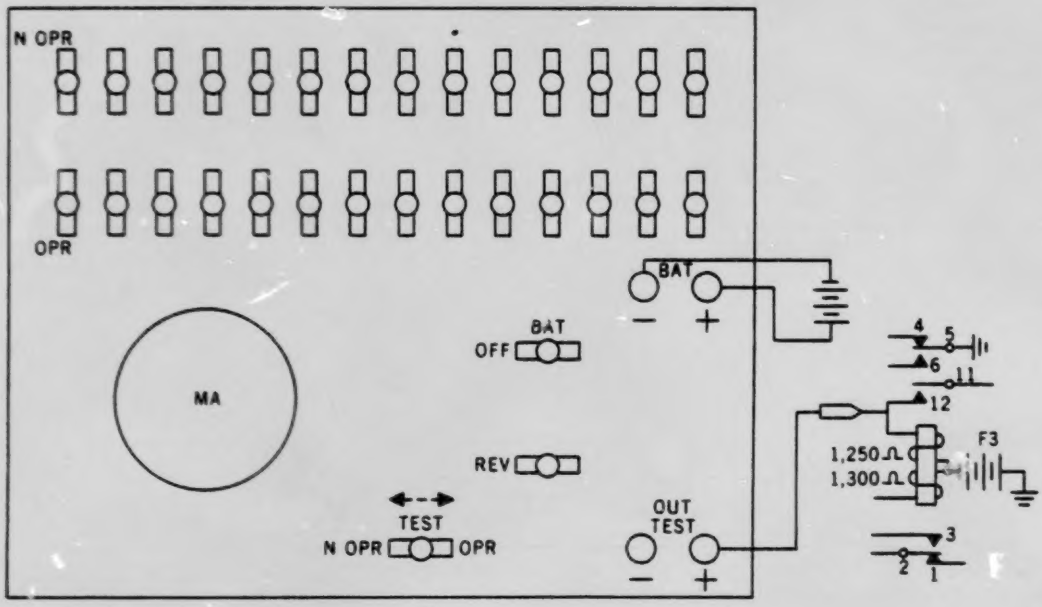


Figure 1-17. Panel illustration of current flow test set.

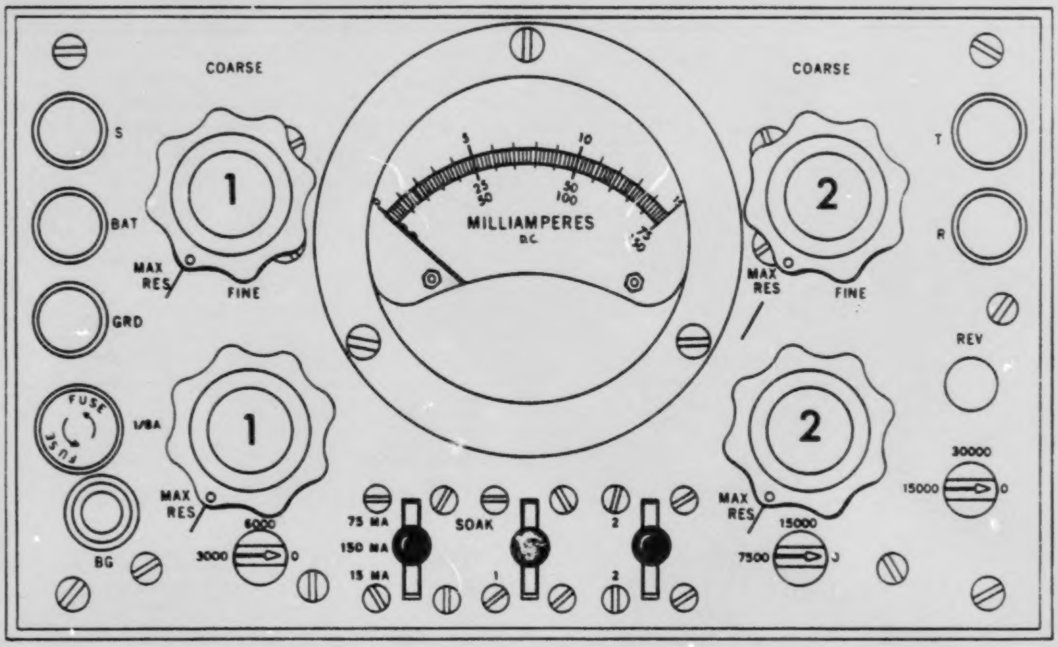


Figure 1-18. Drawing of face of I-181 test set.

5. Where would you connect the positive lead from the current flow test when adjusting the E relay?

202. Given a list of relay items, identify the tool(s) and/or test equipment used to adjust each.

Now that that the relay components and the adjustment sheet are fresh in your mind, let's talk about the tools and test equipment necessary to do the adjusting.

You would never think to work on your car's carburetor with a 2-pound ball peen hammer or your wristwatch with long nose pliers. Special jobs require special tools and test equipment.

When adjusting relays you need a device that provides current in specified amounts and tools designed for the type of relay you are working on.

Current Flow Test Set. Several types of current flow test sets are available for use by switching center repairmen. Each is designed to be connected in series with relays or other electrical apparatus to be tested. The primary function of the set is to measure and control the current on the winding of the relay or similar electromagnetic devices. The resistance of the test set is adjustable. When adjusting the resistance, you cause the current in the relay circuit to conform to the current value specified in a relay adjustment sheet. Figure 1-17 illustrates the control panel of one test set. We have simplified the figure; therefore, we are not picturing all the control devices of the set. You can see that the top row of switches is identified as the nonoperate switch row. The row of switches below the nonoperate switches provide connections which operate the relay under test. Two terminals at the right of the set are to be strapped to the battery source; therefore, they are identified as BAT binding posts. To the left of the BAT binding posts is a battery cutoff switch. Below this latter switch is a reversing switch which reverses the battery connections to the relay circuit. Figure 1-17 also shows a DC milliammeter which registers the current in the relay circuit. To the right of the milliammeter are the TEST key and the OUT TEST binding posts.

Another current flow test set used in testing relays and switches is illustrated in figure 1-18. It has the COARSE and FINE controls which permit you to adjust the resistance of the relay test circuit. It is evident that each control has an indicating dot which you position beside MAX RES for the maximum circuit resistance. In addition, there are two 3-position twist-type keys. One key can be selected for 0, 3,000, or 6,000 ohms while the other permits selection of 0, 7,500, or 15,000 ohms. The

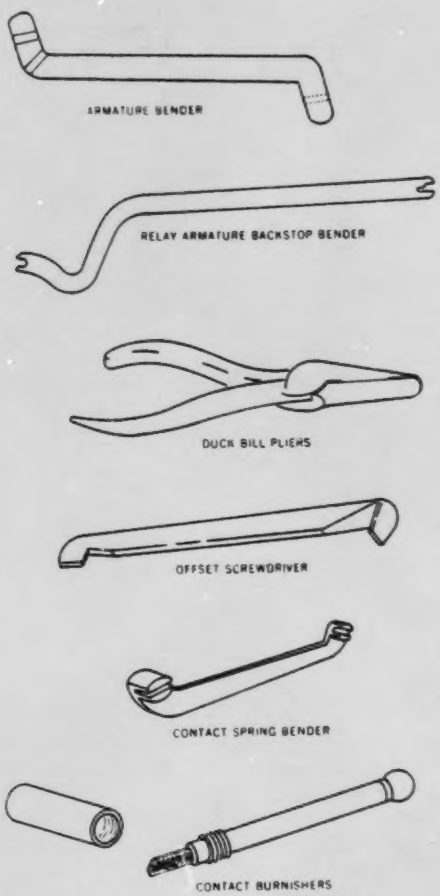


Figure 1-19. Relay adjusting tools.

keys are used in association with the COARSE and FINE controls with which they are aligned. For example, the 3,000-6,000-0 key is used with the two number 1 control knobs. These variable resistance controls provide the same conditions as the 28 operate and nonoperate switches of the former current flow test set. This test set is a smaller and more easily carried unit. Although there are additional controls and terminals on the unit of figure 1-18 (for example, the 75-150-15 MA meter selection key), we are not describing them. Remember: The operating instructions are provided in an Air Force technical order. Use it when preparing to operate and when operating the test set. Regardless of each set's development, the tests that you can make with each are identical.

Adjustment Tools. In order to perform adjustments on relays, you will use certain types of adjusting tools.

Some of the most frequently used tools are pictured in figured 1-19. The purpose of the tools follows:

a. Armature bender. This tool is used to bend the armature when such an adjustment is necessary.

b. Relay armature backstop bender. This tool is used for bending the armature backstop on relays which are not provided with a backstop screw.

c. Duckbill pliers. These pliers are used for straightening and tensioning the relay contact springs.

d. Offset screwdriver. The offset screwdriver is used to loosen or tighten the relay adjusting screws.

e. Contact spring bender. The bending tool is used to bend the contact springs to obtain proper setting and tension.

f. Contact burnishers. The contact burnisher is used for cleaning and burnishing the relay spring contacts.

Exercises (202):

Name the tool(s) and test equipment necessary to adjust the following items.

1. Airline.

2. Residual.

3. Stroke.

4. Contact springs.

5. Operate/Nonoperate requirements.

203. Given statements describing relay adjustment problems, state what adjustment(s) need to be made and what tool(s) should be used for each adjustment.

Adjustment Relationships. As a 3-skill-level repairman, being able to adjust a relay is very necessary; as a 5-skill-level repairman more is required, not only in your proficiency, but in your head. It is necessay for you to understand how various adjustments affect others. For this reason, we discuss that problem briefly at this point. It is not difficult and you already have the needed information; we just need to look at it from a new angle.

Residual adjustment. The residual adjustment is primarily made for the purpose of helping to overcome residual magnetism as the magnetic field of a releasing relay collapses. If you change the residual adjustment from .006 inch to .008 inch you have done what to the travel of the armature? What about the stroke and the spring contacts? STOP READING AND THINK ABOUT IT! Once you think you have an answer, continue on.

First of all, you have reduced the travel of the armature itself and the stroke adjustment too. Most important, the spring contact adjustment has been totally wiped out, especially if the armature is a short lever armature. The same would hold true, only in reverse if you change the residual adjustment from .006 inch to .004 inch.

Armature arm. The armature arm is adjusted so that the make or break adjustment of contacts 1 and 2 meet specifications. It also affects the stroke setting as well as the adjustment of the rest of the spring contacts.

Airline. The airline adjustment affects not only the speed that the relay operates at, but also if the armature will pull up fully.

Exercises (20[illegible]):

State what adjustment(s) is/are required and what tool(s) should be used for each of the problems listed below.

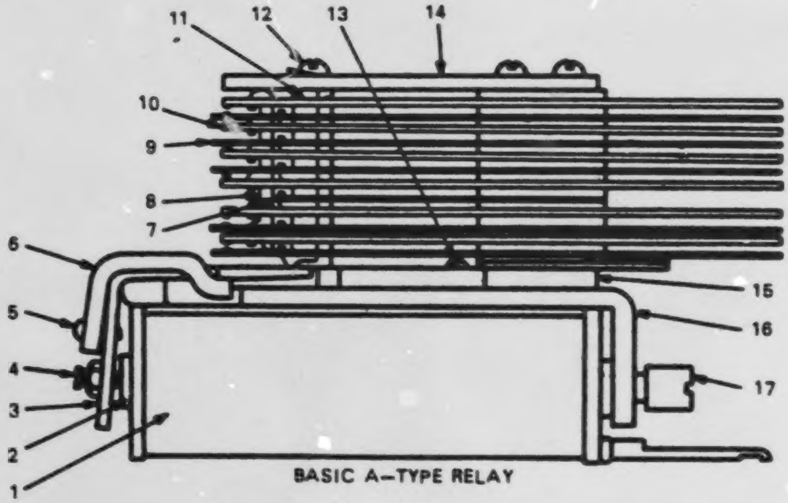
1. Relay spring contacts travel too far when the relay operates and the residual adjustment is correct.

2. Relay does not operate fully and the contact spring tension requirement for operate value is correct.

3. Relay releases much slower than it should and it is not a slow-to-release relay and the spring contact adjustment is correct.

1-2. Stromberg-Carlson Relays

As we said earlier, Stromberg-Carlson relays are constructed somewhat different than Automatic Electric relays. In this section we look at the differences in the relays, adjustment sheet, and adjustments.



1. COIL
2. COIL CORE
3. ARMATURE RESIDUAL PLATE
4. RESIDUAL SCREW AND NUT
5. ARMATURE SUPPORT PLATE MOUNTING SCREW
6. ARMATURE SUPPORT PLATE
7. FORCE SPRING
8. HEAVY STOP
9. LIGHT SPRING
10. HEAVY SPRING
11. PUSHER
12. CLAMPING PLATE SCREWS (4)
13. MOUNTING PLATE SCREW
14. CLAMPING PLATE
15. MOUNTING PLATE
16. FRAME
17. COIL MOUNTING STUD NUT AND WASHER

HC—033C

Figure 1-20. Location of A-type relay components.

204. Given a picture of a Stromberg-Carlson relay, identify selected components.

Relay Types. The two types of Stromberg-Carlson relays that you are concerned with are the A-type and C-type.

A-type. The A-type relay, figure 1-20, consists of four major assemblies: frame, coil, armature assembly, and dual-spring combinations assembly. Some A-type relays may be equipped with only a single spring combination assembly (spring pileup). All of these components are mounted on a single frame.

The frame (16) functions as a mounting base for all the major components of the relay. Two holes are provided at the rear of the frame to mount the relay to the circuit plate. The frame also acts as a magnetic return path for the core, which strengthens the magnetic field acting on the relay. A spring retainer is welded to the top of the frame at the armature end. This holds the armature assembly in place on the frame by means of its spring clip action, but allows the armature assembly to move freely on its pivot at the front of the relay frame.

The coil core (2) is insulated from the coil (1) by a sleeve of triple layer cellulose acetate. The coil windings are made of enamel insulated wire and may be single or double wound around the core. The assembled coil is fastened to the rear of the relay frame by means of a threaded stud and a nut (17). When energized, the coil acts like an electromagnet, attracting the armature to the coil core.

The armature assembly consists of four parts: armature residual plate (3), residual screw (4), armature support plate (6), and armature support plate mounting screw (5). The armature is held in place by means of a metal spring retainer. When the relay operates, the armature pivots on its knife-edge bearing which produces an upward movement beneath the springs. This movement actuates the spring pusher (11) which actuates the moveable light springs (9) so that they make or break contact with the stationary heavy springs (10).

The armature residual plate is equipped with a welded nonmagnetic disk (projection) or an adjustable screw. The projection of the residual determines the operated airgap. This prevents the armature of a deenergized relay from sticking to the coil core because of residual magnetism.

The armature support plate is attached to the armature residual plate by means of an armature support plate mounting screw. The armature travel may be varied by rotating the screw.

The spring combination assembly generally consists of two separate spring combination assemblies (pileups) joined together into a single assembly with a clamping plate (14) at the top and a mounting plate (15) at the bottom. The entire assembly is mounted at the top of the relay frame with a mounting plate screw (13) and a clamping plate screw (12). Phenolic spring pushers (11),

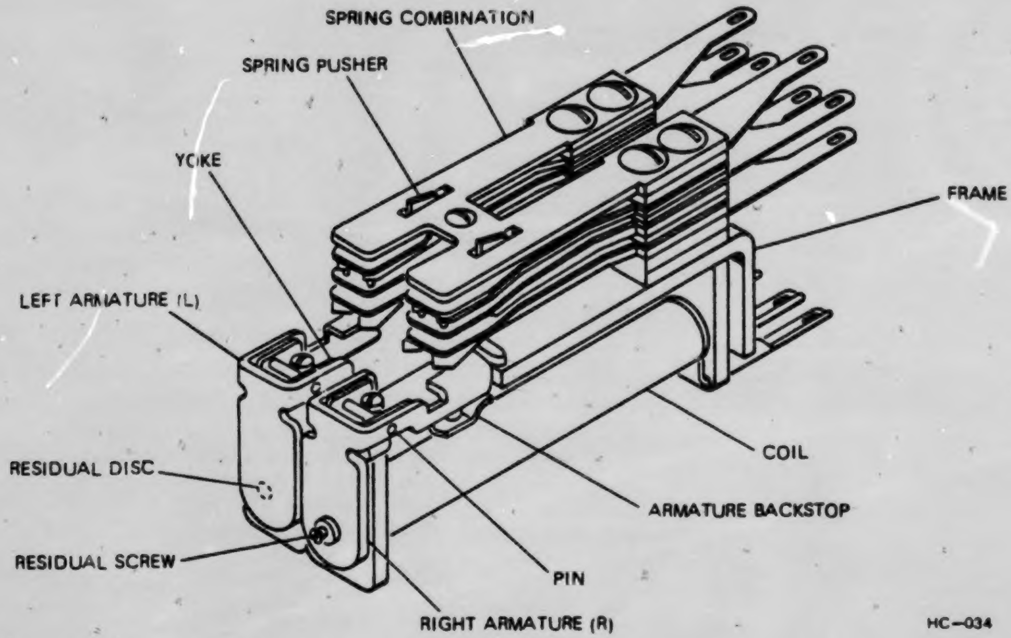


Figure 1-21. Location of C-type relay components.

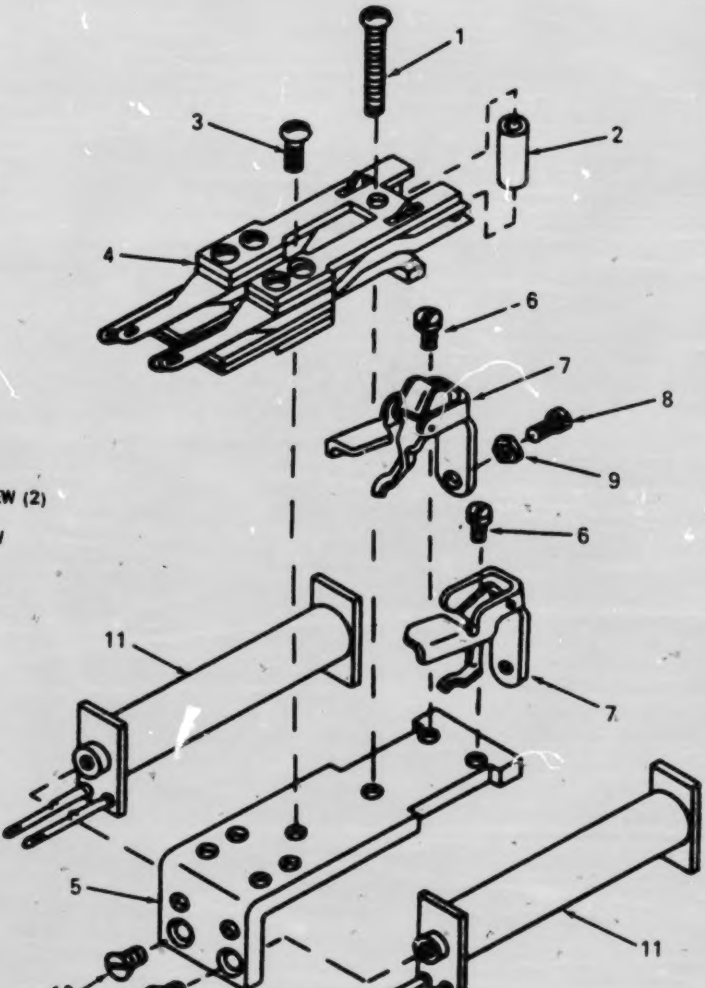
inserted through clearance slots in each spring of the spring pileup, act to move the moveable light springs (9) of each pileup upward when the pusher itself is actuated in an upward direction by the armature of an energized relay. This causes the springs to make or break, thus opening or closing circuits.

C-type. The C-type relay, figures 1-21 and 1-22, is equipped with dual spring pileups which may be composed of one or more of the standard spring combinations. Each relay section operates its own spring pileup independently of the other. The total number of springs in a single pileup may not exceed 20.

The parts of the C-type relay are basically similar in construction, function, and operation to those of the A-type relay. The only exception is the armature.

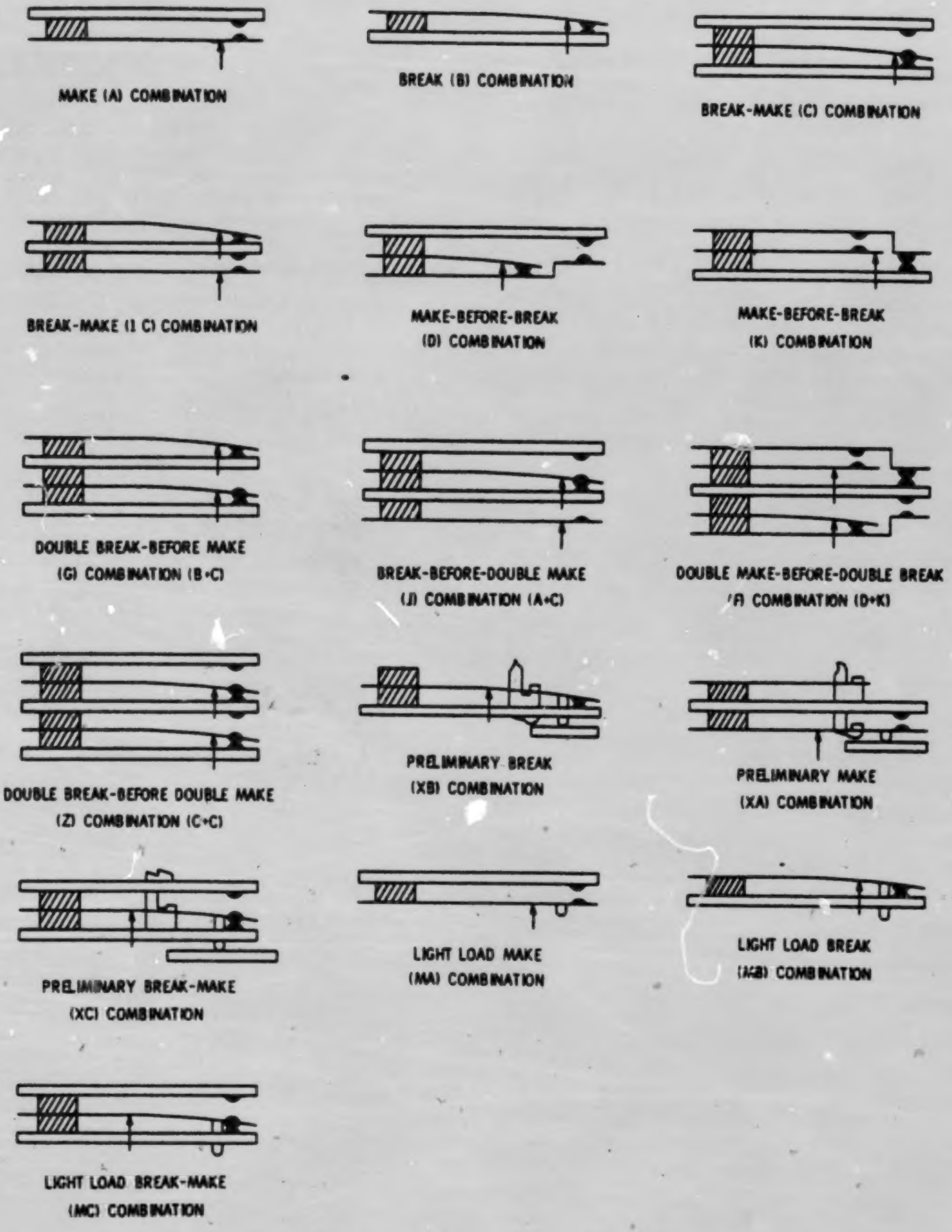
The relay uses two separate armature assemblies. Each armature operates its own spring pileup. Both armatures may be equipped with a nonadjustable residual disk or an adjustable residual screw. Each armature is pivoted on a nonmagnetic pin mounted in a brass yoke.

Spring Combinations. Spring combinations are made up of a combination of light, heavy, and force springs separated by insulators. The various types of spring combinations are shown in figure 1-23.



1. CLAMPING PLATE SCREW
2. SPACER
3. MOUNTING PLATE SCREW
4. SPRING PILEUP
5. FRAME
6. ARMATURE MOUNTING SCREW (2)
7. ARMATURE ASSEMBLY (2)
8. ARMATURE RESIDUAL SCREW
9. ARMATURE RESIDUAL NUT
10. COIL MOUNTING SCREW (2)
11. COIL (2)

Figure 1-22. C-type relay, exploded view.



MAKE (A) COMBINATION

BREAK (B) COMBINATION

BREAK-MAKE (C) COMBINATION

BREAK-MAKE (I C) COMBINATION

MAKE-BEFORE-BREAK
(D) COMBINATION

MAKE-BEFORE-BREAK
(K) COMBINATION

DOUBLE BREAK-BEFORE MAKE
(G) COMBINATION (B+C)

BREAK-BEFORE-DOUBLE MAKE
(J) COMBINATION (A+C)

DOUBLE MAKE-BEFORE-DOUBLE BREAK
(F) COMBINATION (D+K)

DOUBLE BREAK-BEFORE DOUBLE MAKE
(Z) COMBINATION (C+C)

PRELIMINARY BREAK
(XB) COMBINATION

PRELIMINARY MAKE
(XA) COMBINATION

PRELIMINARY BREAK-MAKE
(XC) COMBINATION

LIGHT LOAD MAKE
(MA) COMBINATION

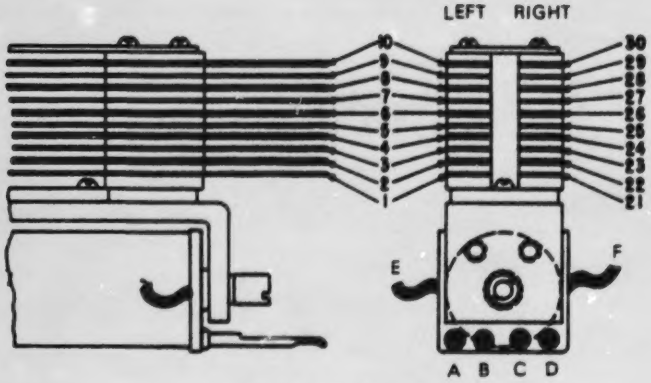
LIGHT LOAD BREAK
(MB) COMBINATION

LIGHT LOAD BREAK-MAKE
(MC) COMBINATION

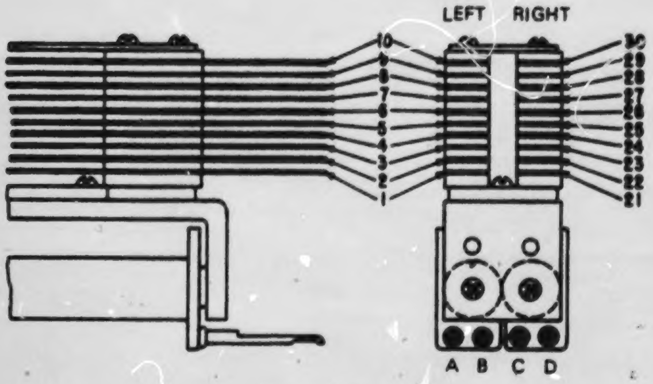
NOTE: ALL COMBINATIONS ARE SHOWN IN NON-OPERATED POSITION.

HC-039

Figure 1-23. Spring combinations.



A. A–TYPE RELAY



B. C–TYPE RELAY

HC–040

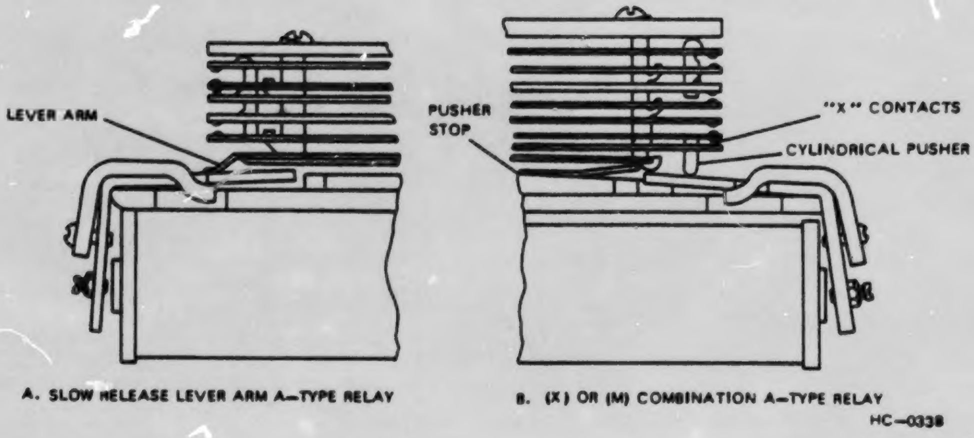
Figure 1-24. Spring contact numbering.

Special types, such as M and X, are also shown. The M-type requires a smaller movement of the armature to operate its contacts. The X-type operates before other combinations in the same pileup. Any combinations that are mounted on a limited travel relay are designated L. The limited travel relay has a large residual screw and special adjustment requirements. Pulsing relays are usually limited travel relays.

Spring Numbering. The method of numbering springs of relay spring pileups for both A- and C-type relays is shown in figure 1-24. Position the relays with the spring pileups on top of the frame and the spring connection terminals (rear of the relay) facing you. For dual spring pileups, two series of numbers are used, 1 to 20 for the left spring pileup and 21 to 40 for the right spring pileup. For a single spring pileup only the series 1 to 20 is used. The spring numbering begins at the bottom of the pileup and proceeds upward with every spring being numbered. No more than 20 springs may be in a single pileup.

Coil Terminals. The A-type relay coil terminals are designated from left to right A, B, C, and D. If the relay is single wound the winding generally begins at terminal A and ends at terminal C. In some coils, such as the coils of slow to release relays, the winding begins at terminal A and ends at terminal D. In a double-wound coil, the second winding begins at the B terminal and ends at the D terminal. Should there be a third winding (tertiary winding), the ends of the windings are brought out by means of flexible leads and connected as required. These leads are designated E and F. The winding begins at E and ends at F.

The C-type relay coil terminal designations A, B, C, and D are the same as the A-type relay. Each of the two coils of the C-type relay has a single winding. One coil winding begins at A and ends at



A. SLOW RELEASE LEVER ARM A—TYPE RELAY

B. (X) OR (M) COMBINATION A—TYPE RELAY

Figure 1-25. A-type relay armatures.

B, whereas the other coil winding begins at C and ends at D.

Classification of A- and C-type Relays. There are four relay classifications: slow-acting, slow-to-operate, slow-to-release, and fast-acting.

Fast-acting. The fast acting relay has a range of operating time of .008 to .020 seconds and a range of release time of .008 to .020 seconds.

Slow-acting. The range of operate and release time depends on several factors, such as pileup, number of coil winding turns, and current flow. Retarded operation and release is also accomplished by a copper sleeve over the coil core. This delays the buildup and collapse of the magnetic field.

Slow-to-operate. Slow operating relays may have a range of operate time of .020 to .130 seconds and a release time of .110 and .210 seconds. This type of relay has a copper slug at the armature end which causes a time delay between its circuit closure and relay operation.

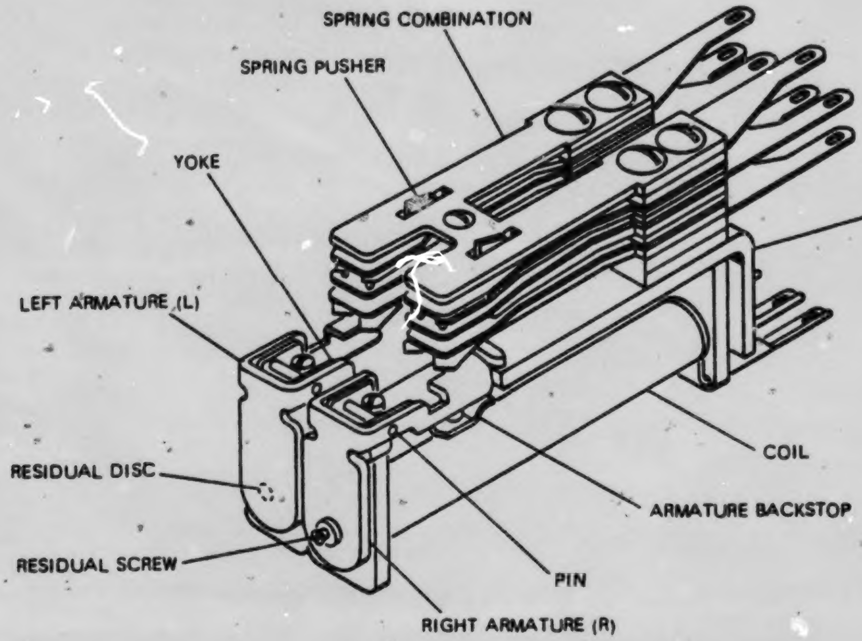


Figure 1-26. C-type relay armatures.

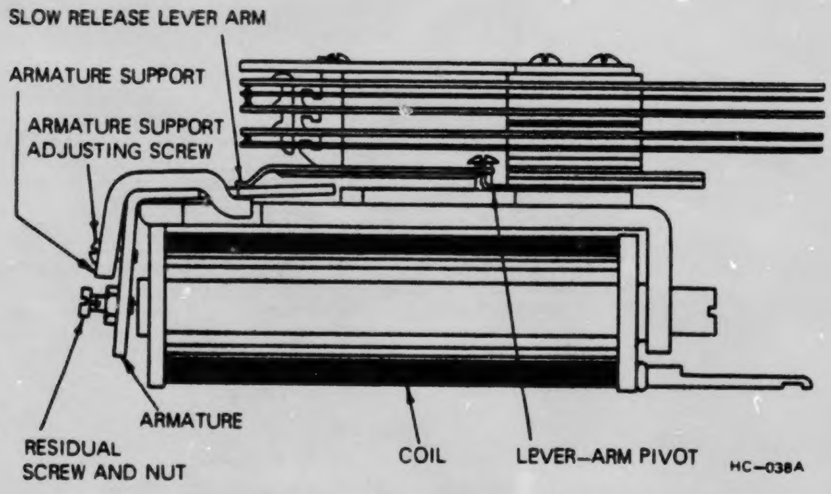


Figure 1-27. A-type relay.

Slow-to-release. Slow releasing relays may have a range of operate time of .005 to .095 second and a release time of .045 to .135 second. The copper slug is located at the heel end of the coil core to delay the magnetic flux action. This allows the relay to remain in the operated condition for a short time after the electrical circuit has been removed.

Standard Ratio Lever Armature Relays. This type of relay is used when a fast acting feature is desired. The A- and C- type relays both employ this standard ratio armature but they do differ in construction.

The A-type relay armature arm pushes the spring pusher at its end, creating this standard ratio. The C-type relay has its armature pivot pin located in a forward position so as to give this ratio. See figure 1-25 for the standard ratio A-type relay and figure 1-26 for the standard ratio C-type relay.

Short Lever Armature Relay. When a long release time or other special circuit conditions must be met, short lever armature relays are used. The A-type relay has a slow-to-release lever arm which the armature presses against the armature arm which presses the pusher giving the 1 to 1 ratio (see fig.

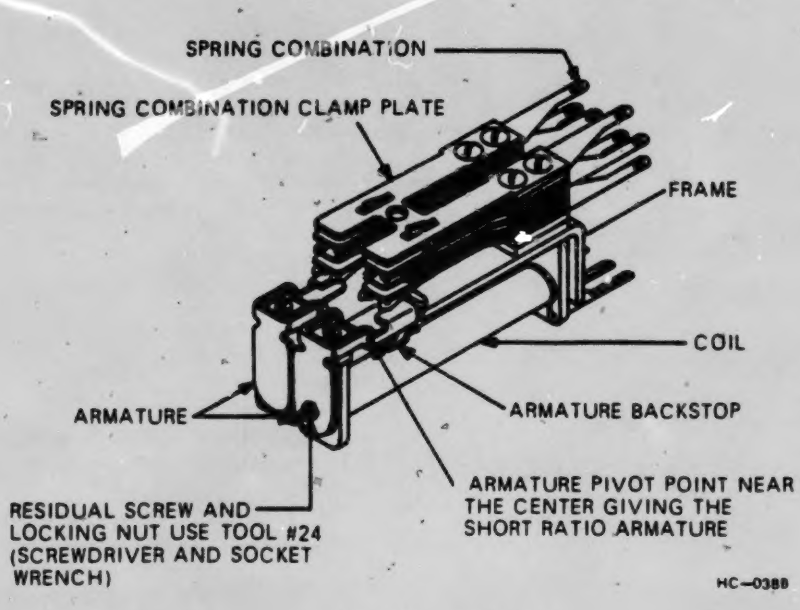

SPRING COMBINATION
SPRING COMBINATION CLAMP PLATE
FRAME
COIL
ARMATURE
ARMATURE BACKSTOP
ARMATURE PIVOT POINT NEAR THE CENTER GIVING THE SHORT RATIO ARMATURE
RESIDUAL SCREW AND LOCKING NUT USE TOOL #24 (SCREWDRIVER AND SOCKET WRENCH)
HC—038B

Figure 1-28. C-type relay.

1-27). The C-type relay has the pivot pin mounted in a center position giving the 1 to 1 ratio (see fig. 1-28).

Exercises (204):

Label the relay parts marked by callouts in figure 1-29.

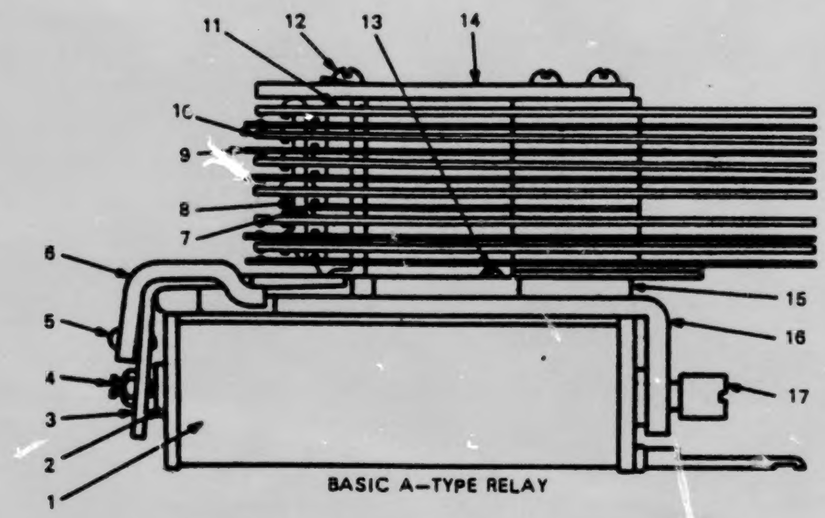


Figure 1-29. Basic A-type relay (objective 204, exercises 1 through 9).

1. 17.

2. 13.

3. 6.

4. 5.

5. 15.

6. 14

7. 1.

8. 16.

9. 3.

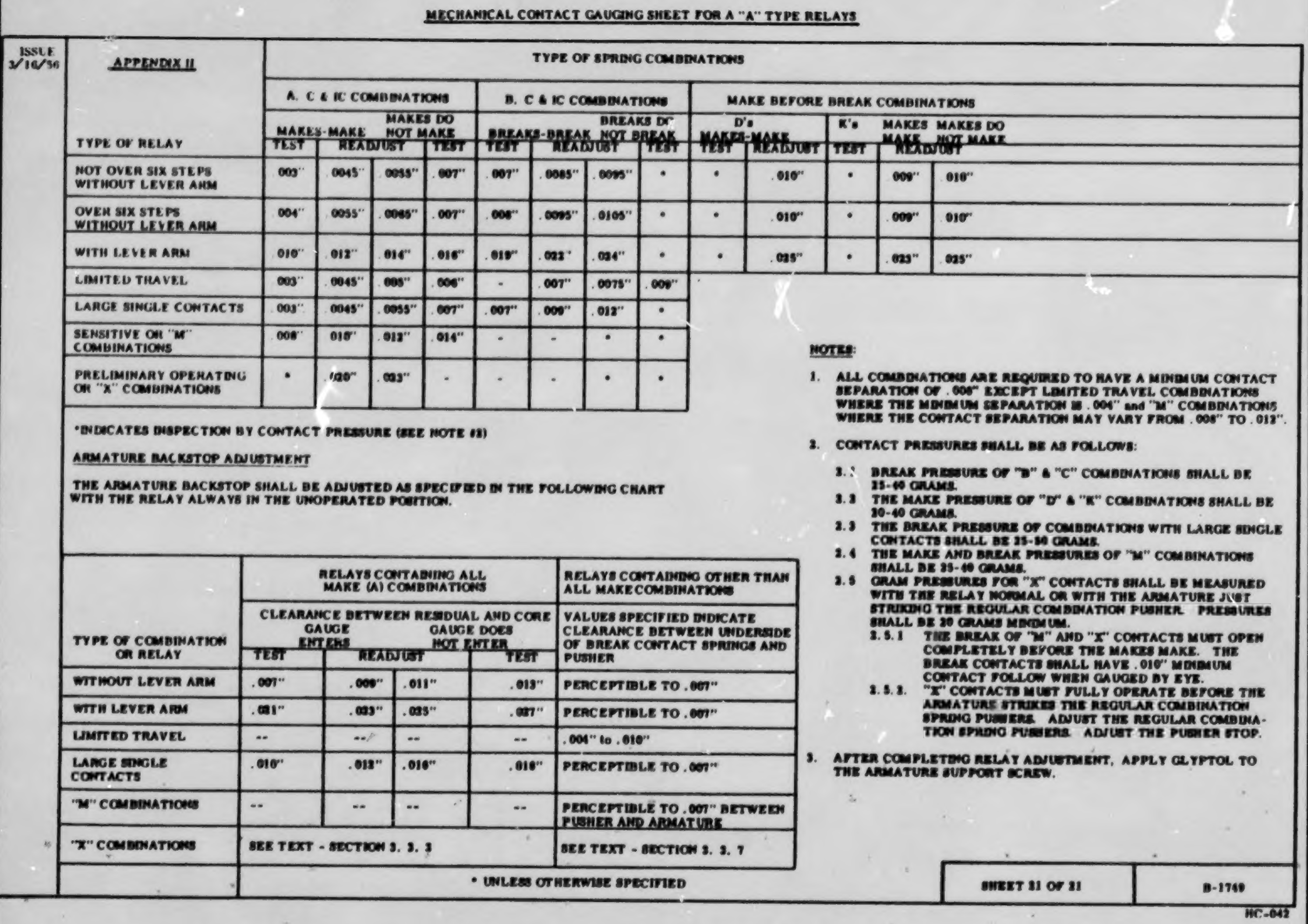
205. Given relay adjustment sheets, interpret selected portions.

Relay Adjustment. The adjustment of XY relays is considerably different from that of Strowger relays. Two things do remain the same; however, the adjustments are important to the operation of the central offices and if you go a step at a time, it isn't difficult.

Mechanical Contact Gauging Sheet for A- and C-Type Relays. These sheets (figs. 1-30 and 1-31) provide information used to adjust the relay contact combination for the distance that the armature moves before the springs make or break. This is known as contact gauging. All figures entered on this sheet are in thousandths or ten thousandths of an inch.

The main column on the far left of the sheet is labeled TYPE OF RELAY. This column describes the relay such as: not over six steps without lever arm. This means not more than six hooks on the spring pusher.

The main column in the second position on the sheet is for the A, C, and I contact combinations. This column is divided into two subcolumns labeled "Makes make" and "makes do not make."



MECHANICAL CONTACT GAUGING SHEET FOR A "A" TYPE RELAYS

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APPENDIX II

TYPE OF RELAY	TYPE OF SPRING COMBINATIONS												
	A. C & IC COMBINATIONS				B. C & IC COMBINATIONS				MAKE BEFORE BREAK COMBINATIONS				
	MAKES-MAKE			MAKES DO NOT MAKE	BREAKS-BREAK			BREAKS DO NOT BREAK	D's MAKES-MAKE		K's	MAKES MAKE	MAKES DO NOT MAKE
	TEST	READJUST		TEST	TEST	READJUST		TEST	TEST	READJUST	TEST	READJUST	
NOT OVER SIX STEPS WITHOUT LEVER ARM	.003"	.0045"	.0055"	.007"	.007"	.0085"	.0095"	*	*	.010"	*	.009"	.010"
OVER SIX STEPS WITHOUT LEVER ARM	.004"	.0055"	.0065"	.007"	.008"	.0095"	.0105"	*	*	.010"	*	.009"	.010"
WITH LEVER ARM	.010"	.012"	.014"	.016"	.019"	.022"	.024"	*	*	.025"	*	.023"	.025"
LIMITED TRAVEL	.003"	.0045"	.005"	.006"	-	.007"	.0075"	.009"					
LARGE SINGLE CONTACTS	.003"	.0045"	.0055"	.007"	.007"	.009"	.012"	*					
SENSITIVE OR "M" COMBINATIONS	.008"	.010"	.012"	.014"	-	-	*	*					
PRELIMINARY OPERATING OR "X" COMBINATIONS	*	.020"	.023"	-	-	-	*	*					

*INDICATES INSPECTION BY CONTACT PRESSURE (SEE NOTE #2)

ARMATURE BACKSTOP ADJUSTMENT

THE ARMATURE BACKSTOP SHALL BE ADJUSTED AS SPECIFIED IN THE FOLLOWING CHART WITH THE RELAY ALWAYS IN THE UNOPERATED POSITION.

TYPE OF COMBINATION OR RELAY	RELAYS CONTAINING ALL MAKE (A) COMBINATIONS				RELAYS CONTAINING OTHER THAN ALL MAKE COMBINATIONS
	CLEARANCE BETWEEN RESIDUAL AND CORE				VALUES SPECIFIED INDICATE CLEARANCE BETWEEN UNDERSIDE OF BREAK CONTACT SPRINGS AND PUSHER
	GAUGE ENTERS		GAUGE DOES NOT ENTER		
	TEST	READJUST		TEST	
WITHOUT LEVER ARM	.007"	.009"	.011"	.013"	PERCEPTIBLE TO .007"
WITH LEVER ARM	.021"	.023"	.025"	.027"	PERCEPTIBLE TO .007"
LIMITED TRAVEL	--	--	--	--	.004" to .010"
LARGE SINGLE CONTACTS	.010"	.012"	.016"	.018"	PERCEPTIBLE TO .007"
"M" COMBINATIONS	--	--	--	--	PERCEPTIBLE TO .007" BETWEEN PUSHER AND ARMATURE
"X" COMBINATIONS	SEE TEXT - SECTION 3. 3. 3				SEE TEXT - SECTION 3. 3. 7
	* UNLESS OTHERWISE SPECIFIED				

NOTES:

1. ALL COMBINATIONS ARE REQUIRED TO HAVE A MINIMUM CONTACT SEPARATION OF .008" EXCEPT LIMITED TRAVEL COMBINATIONS WHERE THE MINIMUM SEPARATION IS .004" and "M" COMBINATIONS WHERE THE CONTACT SEPARATION MAY VARY FROM .008" TO .012".
2. CONTACT PRESSURES SHALL BE AS FOLLOWS:
   - 2.1 BREAK PRESSURE OF "B" & "C" COMBINATIONS SHALL BE 25-40 GRAMS.
   - 2.2 THE MAKE PRESSURE OF "D" & "K" COMBINATIONS SHALL BE 20-40 GRAMS.
   - 2.3 THE BREAK PRESSURE OF COMBINATIONS WITH LARGE SINGLE CONTACTS SHALL BE 25-50 GRAMS.
   - 2.4 THE MAKE AND BREAK PRESSURES OF "M" COMBINATIONS SHALL BE 25-40 GRAMS.
   - 2.5 GRAM PRESSURES FOR "X" CONTACTS SHALL BE MEASURED WITH THE RELAY NORMAL OR WITH THE ARMATURE JUST STRIKING THE REGULAR COMBINATION PUSHER. PRESSURES SHALL BE 20 GRAMS MINIMUM.
     - 2.5.1 THE BREAK OF "M" AND "X" CONTACTS MUST OPEN COMPLETELY BEFORE THE MAKES MAKE. THE BREAK CONTACTS SHALL HAVE .010" MINIMUM CONTACT FOLLOW WHEN GAUGED BY EYE.
     - 2.5.2. "X" CONTACTS MUST FULLY OPERATE BEFORE THE ARMATURE STRIKES THE REGULAR COMBINATION SPRING PUSHERS. ADJUST THE REGULAR COMBINATION SPRING PUSHERS. ADJUST THE PUSHER STOP.
3. AFTER COMPLETING RELAY ADJUSTMENT, APPLY GLYPTOL TO THE ARMATURE SUPPORT SCREW.

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Figure 1-30. Mechanical contact gauging sheet for A-type relays.

MECHANICAL CONTACT GAUGING SHEET
FOR "C" TYPE RELAYS
TO BE USED IN CONJUNCTION WITH E-75910

"C" TYPE RELAY & COMBINATIONS	TYPE OF SPRING COMBINATIONS												
	A, C & IC COMBINATION				B, C & IC COMBINATION				MAKE BEFORE BREAK COMBINATIONS				
	MAKES-MAKE		MAKES DO NOT MAKE		BREAKS-BREAK		BREAKS DO NOT BREAK		D'S MAKES-MAKE		MAKES-MAKE		MAKES DO NOT MAKE
	TEST	READJUST		TEST	TEST	READJUST		TEST	TEST	READJUST	TEST	READJUST	
2-1/2 : 1 ARM. RATIO BEARING PIN IN FRONT	.005"	.006"	.0075"	.009"	.010"	.011"	.013"	*	*	.013"	*	.010"	.013"
1:1 ARM. RATIO BEARING PIN TO REAR	.008"	.0095"	.0115"	.013"	.017"	.018"	.020"	*	*	.021"	*	.018"	.021"
LIMITED TRAVEL BEARING PIN IN FRONT	.005"	.0065"	.007"	.0075"	*	.009"	.010"	.0105"					
PRELIMINARY OPERATING OR "X" COMBINATIONS	*	.027"	.031"	-	-	-	*	*					

ARMATURE BACKSTOP ADJUSTMENTS FOR RELAYS HAVING OTHER THAN ALL MAKE "A" COMBINATIONS:

THE ARMATURE BACKSTOP SHALL BE ADJUSTED AS SPECIFIED IN THE FOLLOWING CHART WITH THE RELAY ALWAYS IN THE UNOPERATED POSITION. FOR RELAYS CONTAINING ALL "A" MAKE OR SPECIAL COMBINATIONS, REFER TO TEXT E-75918.

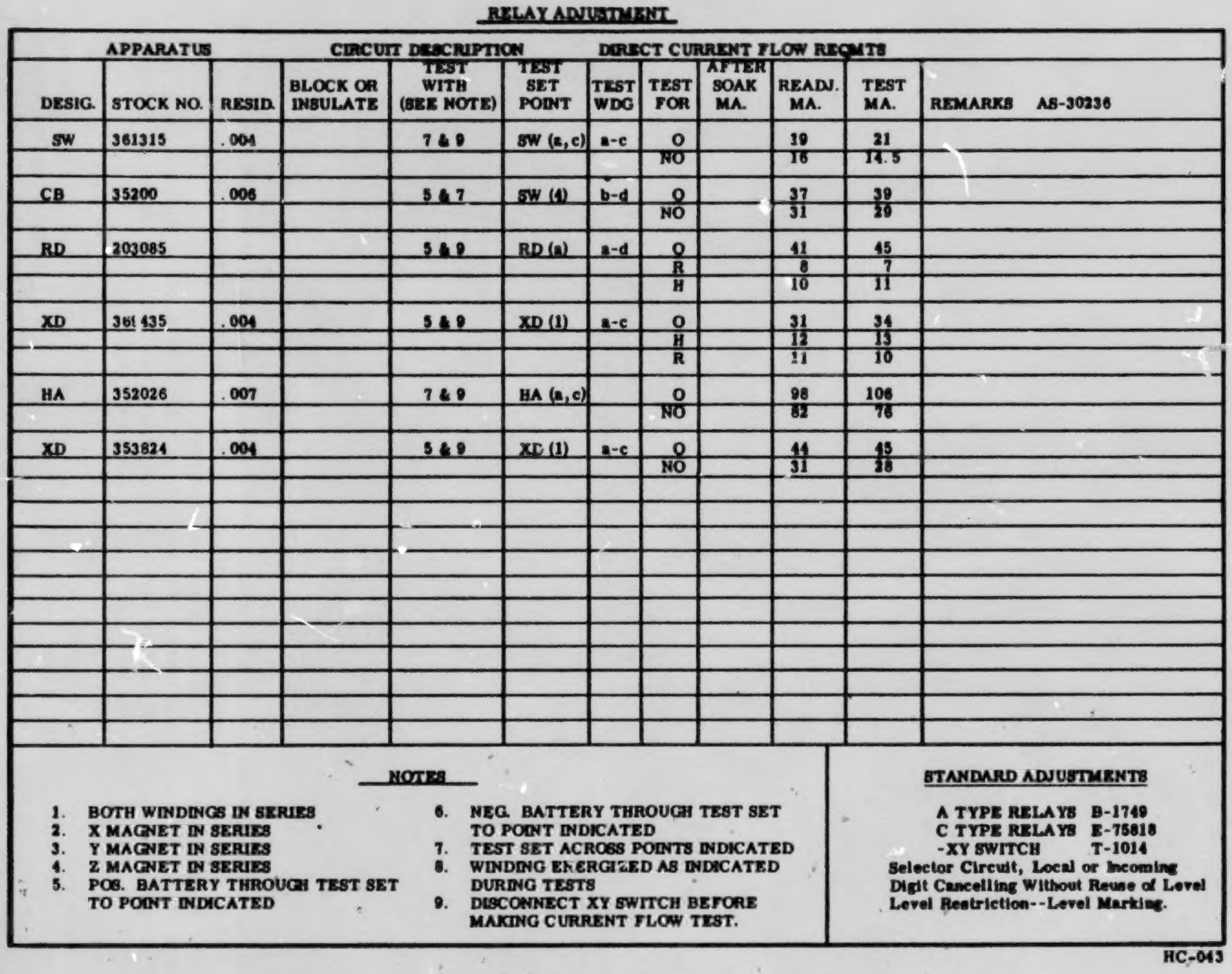
TYPE OF COMBINATION AND RELAY	VALUES SPECIFIED INDICATE CLEARANCE BETWEEN UNDER-SIDE OF BREAK SPRINGS AND PUSHER CRADLE.
BEARING PIN IN FRONT	PERCEPTIBLE TO .008"
BEARING PIN TO THE REAR	PERCEPTIBLE TO .008"
LIMITED TRAVEL	.004" TO .010"
"X" COMBINATIONS	SEE TEXT SEC. F 7

*Indicates Inspection By Contact Pressure (See Note #2)

NOTES:

1. All combinations are required to have a minimum contact separation of .008" except Limited Travel combinations where the minimum separation is .004".
2. Contact Pressures shall be as follows:
   - 2.1 Break Pressure of "B" & "C" combinations shall be 25-50 grams.
   - 2.2 The make pressure of "D" & "K" combinations shall be 20-40 grams.
   - 2.3 Gram pressures for "X" contacts shall be measured with the relay normal or with the armature just striking the regular combination pusher. Pressures shall be 20 grams minimum.
     - 2.3.1 "X" contacts must fully operate before the armature strikes the regular combination spring pusher. Adjust the regular combination spring pushers. Adjust the pusher Stop.
     - 2.3.2 The break of "X" contacts must open completely before the makes make. The break contacts shall have .010" minimum contact follows as gauged by eye.
3. After completing relay adjustment, apply glyptol to the armature support screw.

Figure 1-31. Mechanical contact gauging sheet for C-type relays.



RELAY ADJUSTMENT

APPARATUS			CIRCUIT DESCRIPTION			DIRECT CURRENT FLOW REQMTS					
DESIG.	STOCK NO.	RESID.	BLOCK OR INSULATE	TEST WITH (SEE NOTE)	TEST SET POINT	TEST WDG	TEST FOR	AFTER SOAK MA.	READJ. MA.	TEST MA.	REMARKS AS-30236
SW	361315	.004		7 & 9	SW (a,c)	a-c	O		19	21	
							NO		16	14.5	
CB	35200	.006		5 & 7	SW (4)	b-d	O		37	39	
							NO		31	29	
RD	203085			5 & 9	RD (a)	a-d	O		41	45	
							R		8	7	
							H		10	11	
XD	361435	.004		5 & 9	XD (1)	a-c	O		31	34	
							H		12	13	
							R		11	10	
HA	352026	.007		7 & 9	HA (a,c)		O		98	106	
							NO		82	76	
XD	353824	.004		5 & 9	XD (1)	a-c	O		44	45	
							NO		31	28	

NOTES

1. BOTH WINDINGS IN SERIES
2. X MAGNET IN SERIES
3. Y MAGNET IN SERIES
4. Z MAGNET IN SERIES
5. POS. BATTERY THROUGH TEST SET TO POINT INDICATED
6. NEG. BATTERY THROUGH TEST SET TO POINT INDICATED
7. TEST SET ACROSS POINTS INDICATED
8. WINDING ENERGIZED AS INDICATED DURING TESTS
9. DISCONNECT XY SWITCH BEFORE MAKING CURRENT FLOW TEST.

STANDARD ADJUSTMENTS

A TYPE RELAYS B-1749
C TYPE RELAYS E-75818
-XY SWITCH T-1014
Selector Circuit, Local or Incoming
Digit Cancelling Without Reuse of Level
Level Restriction--Level Marking.

HC-043

Figure 1-32. Electrical relay adjustment sheet.

Use these columns to inspect and adjust the relay with this contact combination. For example, you suspect that an A-type relay with an A contact combination is out of adjustment. This relay is a limited travel relay. Check the spring gauging of this by using the figures in the test column. The relays contact will make with a .003-inch gauge inserted between the armature and the core, and the contacts will not make with a .006-inch gauge inserted between the armature and the core. If the relay does not meet these specifications, it must be readjusted to the ADJ figures, .0045-inch make and .0055-inch not make.

Electrical Adjustment Sheet. The relay adjustment sheet (AS-sheet) is used to make the residual adjustment and the current flow adjustments. Refer to figure 1-32 and start at the left column of the sheet. This first column is labeled Desig and gives the relay's designation as to the circuit it is used in. Directly to the right in the remaining columns are the adjustment specifications for each one of the relays in that particular circuit.

The second column gives the manufacturer's stock number of the relay.

The third column is labeled Residual Projection and gives the specification in thousandths of an inch to which the residual projection should be adjusted.

The fourth column labeled Block or Insulate is used when the relay is adjusted in the circuit plate and it is necessary to block (keep a relay from operating) or insulate relay contacts.

The fifth column is labeled Test With (See Note). If note 1 appears in this column the special instructions for this note will appear in the lower left section of this AS sheet.

The sixth column labeled Test Set Point specifies the relay and springs to which test set leads will be connected. This is used only if the relay is to be adjusted in the circuit plate.

The seventh column, is labeled Test WDG, which tells which winding of the relay you will be checking.

The next column will be labeled Test For, and will have either O, NO, H, or R. The O stands for operate, NO for nonoperate, H for hold, and the R for release. The relay will operate on a specified amount of current. It will not operate on any less current. It will hold on a given current, but will release on a lesser amount. The current values will be found on the next two columns to the right, which are labeled Readj.MA, for readjust milliamps, and Test MA, for test milliamps. The remarks column will give any special instruction needed to adjust the relay.

Exercises (205):

Use figures 1-30, 1-31, and 1-32 to respond to the following.

1. On an A-type relay with a lever arm, at how many thousandths of an inch do A combination makes-make under TEST?

2. What is the residual setting of the XD relay in circuit AS-30236?

3. When adjusting relay SW in circuit AS-30236, what operate and nonoperate values are used?

4. On a C-type relay with a 1:1 armature ratio, at how many thousandths of an inch do B combination breaks-break under READJUST?

206. Given a list of relay adjustments, identify tools and/or test equipment used for each.

Mechanical Adjustments for the A-Type Relay. The A-type relay may be equipped with either a nonadjustable welded disk-type residual or an adjustable residual screw. The residual airgap for relays with or without residual screws is given in the applicable relay adjustment table in figure 1-32. For relays with nonadjustable residuals, it is only necessary that a .002 gauge be loose when inserted between the armature and core of the relay. The adjustable residual screw controls the amount of space between the armature and the coil core with the relay electrically operated. To adjust the residual screw projection for proper air gap, follow the procedure in *a.* through *f.* below:

a. Use a screwdriver and socket wrench to loosen the locking nut slightly.

b. Operate the armature by hand.

c. Insert the specified thickness gauge between the armature and the core while holding the gauge parallel to the pivot edge just clearing the residual screws.

d. Check the fit of the thickness gauge. Adjust the screw until the gauge fits snugly between the armature and the core.

(1) Residual Projections	Loose Fit	Tight Fit
.010 inch or smaller	.001 inch smaller	.001 larger

For example, for a specified residual projection of .004 inch, a .003-inch gauge should fit loosely between armature and the core and a .005-inch gauge should fit tightly.

(2) Residual Projections	Loose Fit	Tight Fit
.010 inch or larger	.002 inch smaller	.002 larger

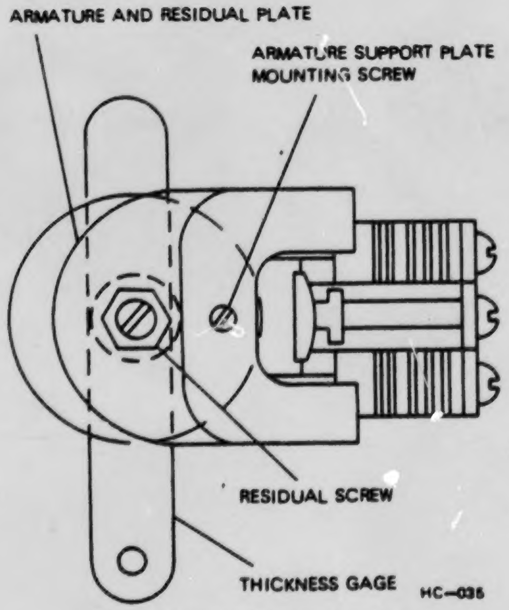

ARMATURE AND RESIDUAL PLATE
ARMATURE SUPPORT PLATE MOUNTING SCREW
RESIDUAL SCREW
THICKNESS GAGE
HC—035

Figure 1-33. Checking contact gauging.

For example, for a specified residual projection of .012 inch, a .010-inch gauge should fit loosely between the armature and the core, and a .014-inch gauge should fit tightly.

e. Recheck the residual projection after tightening the locking nut.

f. For relays which have release time or hold current requirements, the residual screw setting may be varied from the setting specified on the relay adjustment table in order to obtain desired operating characteristics. At all times, however, there must be perceptible residual gap and proper contact pressure.

Making contact gauging. The armature position at which the contacts make and break may be checked by inserting the specified thickness gauge between the armature and the coil core (fig. 1-33). The end of the gauge must just cover the residual projection, and the relay must be electrically operated while making the check. If readjustment is required, turn the armature support plate adjusting screw in the clockwise direction with a small screwdriver. The armature support plate mounting screw should be sealed with glyptol cement. This adjustment will compensate for normal contact wear. If, during adjustment, the screw is turned in too far, remove the armature and armature support and reform the armature by bending it inwards. To seat the armature support plate adjusting screws, it may also be necessary to reform the armature by bending it outward. If a relay has two spring pileups and is badly out of adjustment because of damage, it may be necessary to reform the armature by bending it outward. If a relay has two spring pileups and is badly out of adjustment because of damage, it may be necessary to bend the front end of the spring combination clamping plate to even up both pileups. This will cause the make contacts or both pileups to make at the same time.

Break contact gauging. When the make contacts are properly adjusted, the break contacts will probably be in correct adjustment. However, if readjustment is necessary, the front end of the heavy break springs may be adjusted with the spring adjusting tool. EXTREME CAUTION: During this adjustment, be very careful not to damage the pusher or stop. If after the heavy spring adjustments have been made, the relay fails to meet its specified electrical requirements, adjust the tension of the break springs by using the proper spring adjustment tool. The tool selected will depend on the thickness of the spring to be adjusted.

Armature backstop adjustment (see fig. 1-34). Insert the projection of the adjusting tool into the hole in the armature backstop and twist this section of the armature to meet the requirements.

Pressure gauging (see fig. 1-35). Adjust the tension of the break springs with the proper adjusting tool, check the pressure with a pressure gauge. This adjustment will only be necessary if the adjustment sheet calls for specific contact pressure.

Mechanical Adjustments for the C-Type Relay. The settings of the residual screws on relays equipped with adjustable residuals are specified in the relay adjustment sheet.

For residual projections specified as .010 inch and smaller, a gauge .001 smaller shall be loose and a gauge .002 inch larger shall be tight when inserted. For residual projections specified as .011

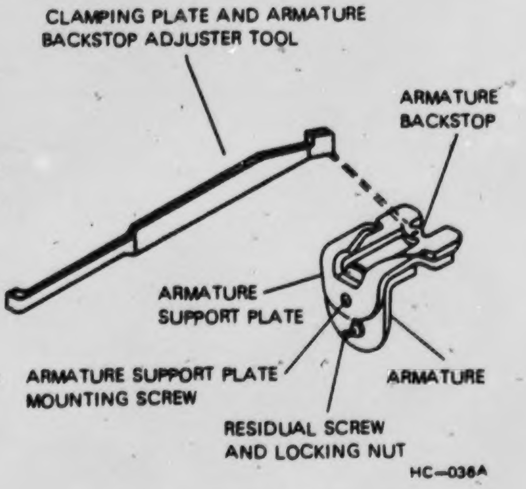

CLAMPING PLATE AND ARMATURE BACKSTOP ADJUSTER TOOL
ARMATURE BACKSTOP
ARMATURE SUPPORT PLATE
ARMATURE SUPPORT PLATE MOUNTING SCREW
ARMATURE
RESIDUAL SCREW AND LOCKING NUT
HC—036A

Figure 1-34. Adjusting armature backstop.

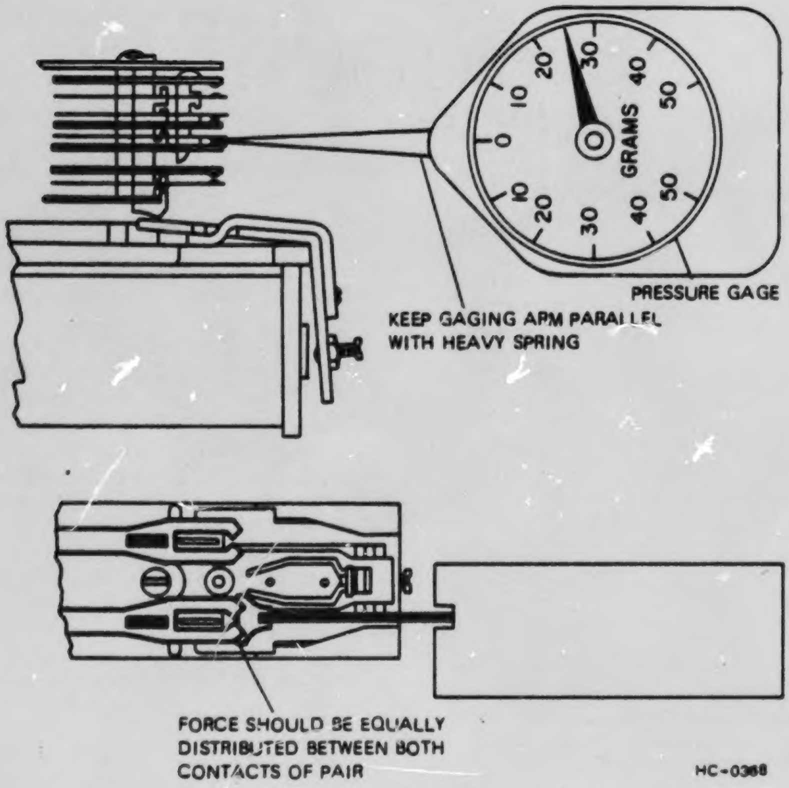

10
20
30
40
50
0
10
20
30
40
50
GRAMS
PRESSURE GAGE
KEEP GAGING ARM PARALLEL WITH HEAVY SPRING
FORCE SHOULD BE EQUALLY DISTRIBUTED BETWEEN BOTH CONTACTS OF PAIR
HC-0368

Figure 1-35. Checking contact spring pressure.

inch or larger, a gauge .002 inch smaller shall be loose and a gauge .002 inch larger shall be tight when inserted.

For relays with the nonadjustable welded type residuals, no adjustment is necessary, but they should be inspected to see if a .002 inch gauge is loose when inserted. For relays which have release time or hold current requirements, the residual setting may be varied from that specified to obtain the desired characteristics but they must always have a perceptible residual airgap.

Contact gauging. When the light spring is a part of a break combination it should be adjusted so that the pusher must move from .005 inch to .007 inch before touching this light spring. All the heavy springs whether they are part of a make or break combination should be against the spring stop.

The armature position at which the contacts make and break may be checked by inserting the specified thickness gauge between the armature and the coil core. The end of the gauge must just cover the residual projection and the relay must be electrically operated while making the check. If adjustment of the make springs is required bend the light springs with a spring bender of the correct size. To adjust the break combinations bend the heavy springs with the spring bender. Extreme caution should be taken when adjusting the heavy springs to prevent breaking the pushers and stops.

Backstop setting. The relays having make contact combinations only, the back stop will be adjusted as follows: standard lever ration armatures—the backstop will be adjusted so that a .012 inch gauge will enter freely between the residual and core and a .014 inch gauge will not enter.

Electrical Adjustment for the A- and C-Type Relays. The current flow test set will be used to adjust the A- and C-type relays for the operate and nonoperate values. The relay adjustment sheet will give the current values that the relay is to be adjusted to. If the relay operates on both the operate and nonoperate values, place more tension on the short force springs until the relay operates on the operate value but will not operate on the nonoperate value.

If the relay will not operate on the operate value, remove some of the tension on the force springs.

Exercises (206):

State what tools and test equipment are required to make each of the adjustments listed below.

1. Residual.

2. Backstop.

3. Spring tension, break springs.

4. Make or Break.

5. Operate or Nonoperate value.

207. Given statements describing relay adjustment problems, identify what adjustment(s) needed to be made.

As we said in our study of Strowger relays, how one adjustment effects others is a knowledge you need in order to properly adjust and troubleshoot relays.

Adjustment Relationships. The adjustment relationships of a Stromberg-Carlson relay are, in most cases, considerably different from Strowger relays because their construction is considerably different.

A-type residual screw adjustment. The residual screw adjustment not only determines how quickly the armature restores when the relay is deenergized; it also determines the amount of armature residual plate travel when the relay operates. It also works with the armature support plate and its adjusting screw to determine the amount of travel of the spring pusher which causes the spring contacts (light) to move.

A-type backstop adjsutment. The backstop adjustment affects the stopping point of the armature residual plate when the relay is deenergized; it also affects distance between the light (movable) springs and the heavy (stationary) springs when the relay is deenergized. Changing this adjustment necessitates readjusting the armature support plate.

C-type residual screw adjustment. About the only difference between the C-type relay and the A-type, so far as the residual screw adjustment goes, is that this type of relay does not have an armature support plate to contend with.

C-type residual airgap and backstop adjustment. The residual airgap should allow the armature to swing freely on its pin; insure that the gap is an even distance from the frame for the length of the armature pin, and that there is only a perceptible clearance. The backstop adjustment on this type of relay affects the stopping point of the armature and spring contacts of a deenergized relay in much the same way as on the A-type relay.

Exercises (207):

State what adjustment(s) is/are required for each of the problems listed below.

1. The light springs of an A-type relay travel too far when the relay operates. The residual and backstop settings are correct.

2. Sometimes the armature of a C-type relay fails to pull up when the relay is energized or it pulls up slowly. The residual airgap and backstop adjustment are correct.

3. On A-type relay the light spring contacts are touching the preceding numbered heavy spring contacts. The residual screw adjustment is correct.

CHAPTER 2

Telephone Systems Switches

MANY CENTURIES have passed, yet the Romans are still recognized as having been great roadbuilders. Many of their highways, laid hundreds of years ago, are still being used in Europe. Their "engineers" realized that merely laying a road from one main point to another did not provide adequate access for travel to and from any but the "in-line" points. Thus, they evolved the "network" principle of roadbuilding, with crossings or interchanges affording the traveler alternate routing to enable him to select the path that most adequately satisfied his need. This network principle has been reengineered over the years into countless applications where there is a requirement for flexible routing along with efficient traffic-handling capacity. In a similar manner, switches in the dial telephone switching center provide both the routing flexibility and a capacity for handling traffic efficiently.

Homing! Nonnumerical! Numerical! These three words should be familiar to a telephone switching specialist. The first of these could make you think of your own home: that wonderful place so dear to your heart and so filled with joy when you are there. Yes, thoughts of that home where you live may give you a feeling of pleasure, but we must think about another type of home. Stepping-type switching devices usually have a home position, too. A device that returns to the same location (home) at the completion of its operating cycle has been referred to as a homing device. Release of the switch-stepping mechanism permits the device to return to a normal (at-rest) position because of spring action and the force of gravity. A "homing device" is also defined as one that always starts in the correct direction of motion or rotation. From the home position, the switch shaft moves in a specific direction because of a combination of pawls, ratchets, and detents, and as a result of circuit connections made by relays. Therefore, the stepping-type switches fit both descriptions; they return home, and they always start in a prescribed direction of travel. Nonnumerical, in the telephone language, refers to equipment that is completely automatic; therefore, it is not controlled by the dial of the telephone at the calling station. Numerical, to a telephone switchman, refers to equipment that is under the control of the dial at the calling telephone.

2-1. Strowger Switches

The telephone switch completes, interrupts, or changes connections in a telephone system. The switch actions take place with the assistance of relays. The resulting connections complete circuits between vertically and horizontally placed contacts or between individual banks or vertically placed contacts.

We have stated that the progress of a call through the automatic switching equipment is comparable to the progress of a call through the manual switchboard. Removal of the handset starts a series of activities that provide a connection between the calling telephone and the called telephone. In the manual system, the operator completes the call by means of a cord circuit; whereas in the automatic system, relays and switches complete the connections.

The Strowger telephone system uses relays and stepping-type switches. The system works so that one of several operations, or steps, is completed before another begins to progress toward connection.

The Strowger stepping switches are most often referred to as single motion and two motion, because of their construction. Single-motion stepping switches include minor switches and rotary stepping switches. Both types of stepping switches have a stepping mechanism and a set of contacting arms (wipers). The stepping mechanism moves the wipers over a contact bank until they reach the desired contact or set of contacts. The wipers, resting on this contact or set of contacts, complete a connection between two circuits: the circuit that terminates at the wiper is connected to the circuit that terminates at the contact or set of contacts.

Our concern in this section is the Strowger two-motion stepping switch; its makeup, operation, adjustment, and adjustment interactions.

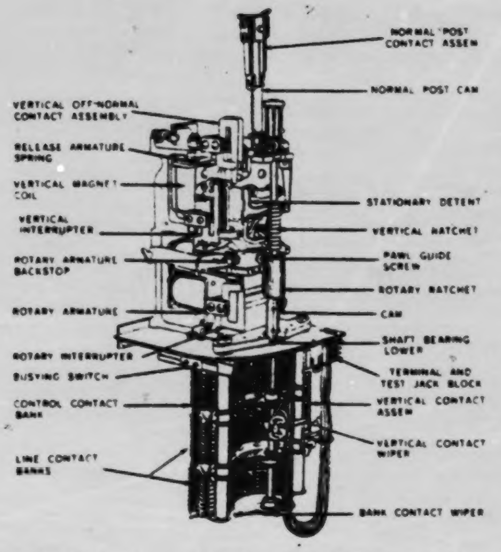


Figure 2-1. Two-motion Strowger switch, half-right view.

208. Given a picture of a Strowger switch, identify selected parts and state the function of each.

Two-Motion Switches. A two-motion stepping switch consists of the shaft, wipers, magnets, cams, pawls, springs, etc., which comprise a stepping mechanism. In addition to this stepping mechanism, you will find two-motion switches that include control relays and a contact bank assembly. The contact bank assembly has the contacts which terminate the conductors of a cable. The wipers of the stepping mechanism touch these contacts when they are stepped to the bank. The control relays govern the electrical circuit of the switch. Figure 2-1 shows a view of the Strowger two-motion stepping switch, and figure 2-2 pictures the same switch, but from the opposite side. Note that these illustrations reveal the contact banks as being a part of the switch. The switch base and control relays are not pictured, but they also are considered to be part of the switch. The vertical magnet operates to start the operation of this Strowger switch. The armature associated with this vertical magnet presses a pawl against a tooth of the vertical ratchet on the switch shaft, thus raising the shaft one step. The wipers are mounted on the shaft; therefore, they move into a position opposite a level in the contact bank. A holding detent prevents the shaft from returning to the home position. Each operation of the vertical magnet steps the shaft over an additional tooth of the ratchet. The stationary detent supports the weight of the shaft during rotary stepping.

The second motion of the switch is a rotation of the shaft. Current in the rotary magnet operates the rotary armature. A pawl attached to the operated armature engages a tooth of the rotary ratchet, rotating the shaft one step horizontally over the level of the contact bank. Each time that the rotary magnet restores, the armature withdraws the pawl from the rotary ratchet. The shaft cannot return to the first position, though, because the rotary detent holds it in the selected position. Each operation of the rotary magnet steps the shaft once horizontally over the contact bank level. Remember, this level of the contact bank over which the wipers are passing was selected by a vertical stepping action. The two motions of this switch, then, are vertical stepping followed by horizontal (rotary) stepping. The wipers are springs, and their tips press against the contacts in the bank assembly; thus they provide an electrical connection when the switch has completed its operation. Wiper cords (conductors) extend from the wipers to a wiper cord terminal strip mounted near the top of the bank assembly. By means of these wiper cords, an electrical circuit can be completed.

The wipers and shaft of the two-motion Strowger switch are restored to the at-rest position when the release magnet operates. The operated release magnet attracts the release armature which, in turn, presses against the double detent. The double detent pivots, thereby withdrawing the vertical and rotary

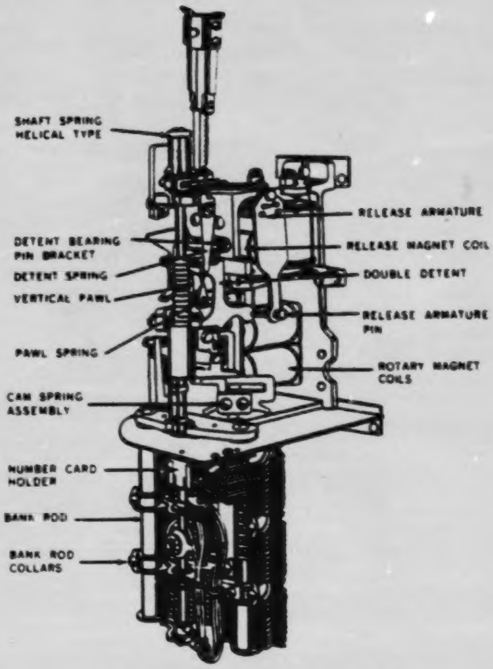


Figure 2-2. Two-motion Strowger switch, half-left view.

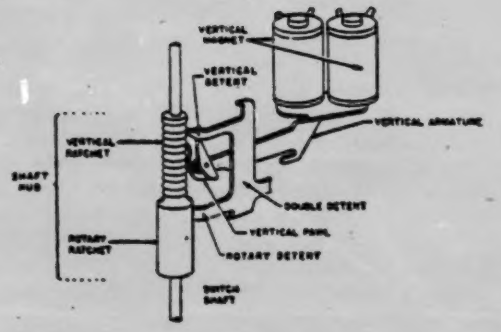


Figure 2-3. Vertical stepping mechanism.

detents from their respective ratchets of the shaft. The double detent is not permitted to return to the ratchets, because of a release link. The release magnet is permitted to restore. A helical spring at the upper end of the shaft, which is tensioned during the rotary action, causes the shaft and wipers to rotate counterclockwise until the wipers clear the bank. The stationary detent prevents the shaft from dropping during this return of the shaft to the left. Gravity restores the shaft to the home position from the raised position.

We have said that stepping switches consist of a stepping mechanism and a set of wipers. They may have one or more banks of contacts. Let us now look at these units in the Strowger two-motion stepping switch more closely.

Stepping mechanism. Figure 2-3 shows a view of the stepping mechanism for the Strowger stepping switch. Isolating the mechanism in this fashion allows for a better understanding of the switching actions and of the position and the function of each component. The vertical magnet is actually two coils which are series connected. Current in their windings causes the vertical armature to move toward the core. Accordingly, the moving armature activates other devices. The small finger that projects from under the vertical armature lifts a release link, which permits the double detent to move against the ratchet under the pressure of the double detent spring. The vertical pawl, which is attached to the vertical armature, moves upward while pressing against the vertical ratchet. Because of this pressure, the elevating vertical pawl lifts the ratchet which, in turn, raises the shaft. The shaft mounts the wipers. Figure 2-3 does not show these wipers, but figure 2-6 does. Each operation of the vertical magnet raises the shaft the distance which equals the length of one tooth of the ratchet. When the vertical magnet restores, likewise releasing the vertical armature, it causes the vertical pawl to be withdrawn from the ratchet. The released pawl is held away from the ratchet teeth by an arm of the stationary detent. Figure 2-4 shows this lower arm on the stationary detent, but it does not show the extension of the vertical pawl (vertical finger) which rests against the arm. The tension of a flat spring restores the armature. This spring is not shown in figure 2-3. Meanwhile, the upper finger (called the vertical detent) of the double detent has slipped under the tooth of the vertical ratchet because of the pressure exerted by the double detent spring. The vertical detent holds the shaft in the raised position. When the switch is not being operated, the double detent is held clear of the shaft ratchets by a flat spring (the release link). Figure 2-5 identifies this release link. The cutout section of the release link drops over a projection on the double detent to hold it out of engagement with the ratchet.

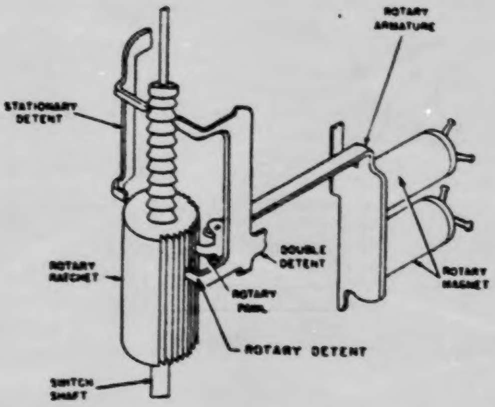


Figure 2-4. Rotary stepping mechanism.

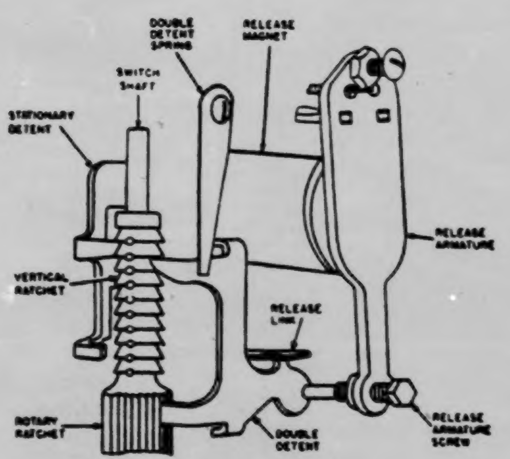


Figure 2-5. Strowger switch release mechanism.

Figure 2-4 pictures a closeup view of the rotary stepping mechanism for the Strowger switch. Again, you can see two series-connected coils which have been given the nomenclature "magnet."

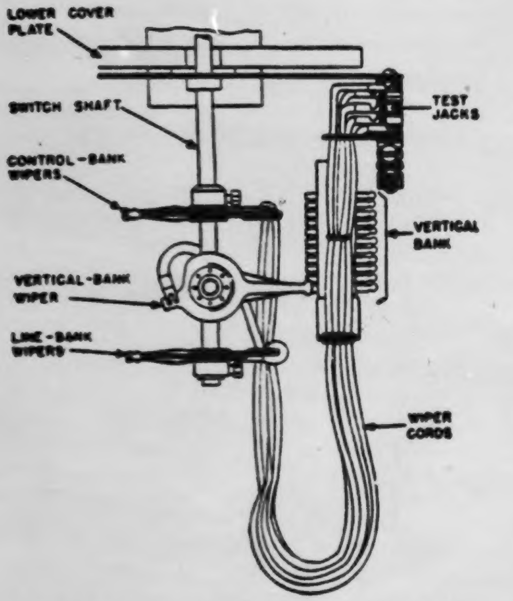


Figure 2-6. Strowger switch contact wiper assembly.

The operating current in this rotary magnet produces a movement of the rotary armature. The rotary pawl, attached to the moving armature, presses against the rotary ratchet. As a result, the switch shaft rotates the wipers horizontally along a level of the contact bank. The stationary detent supports the weight of the shaft during this rotary movement.

NOTE: When the shaft steps vertically, the stationary detent rests within a groove on the side of the vertical ratchet.

Taking the first rotary step moves the groove of the ratchet from the stationary detent and brings the protruding edge of a tooth over the detent; thus a transition is made from the vertical detent's support to stationary detent support. The vertical detent is not able to support the shaft during rotary stepping because there is clearance between it and the edge of the ratchet tooth. This clearance is the result of rotating the small projections on the vertical ratchet. The circles shown at each tooth of the vertical ratchet in figure 2-5 represent these projections. During vertical stepping, the vertical detent rested under such a projection, but during rotary stepping the projection is out of the in-line position. This ratchet projection also allows the stationary detent to slip under the ratchet tooth. Following each release of the rotary magnet, the rotary pawl is withdrawn from the rotary ratchet. A flat spring within the rotary armature presses against an adjusting screw and supplies restoring tension to the armature. A fixed residual on the magnet permits rapid release following termination of current in the magnet operating circuit. The restored rotary armature rests against a stop pin. This stop pin provides that the rotary pawl just clears the shaft during its vertical stepping. The rotary detent holds the shaft in the rotated position until the succeeding action is begun. This action could be another rotary step for the shaft or a release of the switch.

Figure 2-5 is a closeup view of the release mechanism for the Strowger switch. The single coil of this release magnet operates when the current is in the switch releasing circuit. The operated release magnet moves the release armature against the double detent. In response to this pressure from the armature and the armature release screw, the double detent pivots away from the ratchets of the switch shaft and into position for seizure by the release link. Since the rotary detent is withdrawn from the rotary ratchet by the armature action, the helical shaft spring is able to rotate the shaft to clear the wipers from the bank and return the groove of the vertical ratchet to the position of the stationary detent. When the stationary detent slides into this ratchet groove, gravity returns the shaft to the home position. Remember that the double detent spring presses the double detent against the ratchets during switch stepping. Also, the restoring switch restores the vertical off-normal (VON) switch by placing weight onto a lever which, in turn, presses against movable contact springs of the VON switch.

Contact wiper assembly. Figure 2-6 reveals three contact wipers which are mounted at the lower part of the switch shaft—control-bank, vertical-bank, and line-bank wipers. The control-bank wipers are placed higher on the shaft because they must ride over contacts of the control-bank section of the contact bank assembly. This wiper unit consists of springs which have an insulator between them. The lips of the wipers, shown to the left side in figure 2-6, are separated and have a flattened area which permits reliable connection with the bank contact. A pair of wiper cords terminate at the opposite end of the wiper, as shown to the right of the figure.

NOTE: This terminal connection to two cords does not always hold true, because the terminals can be strapped. In this latter case, one wiper cord is sufficient.

The vertical-bank wiper is placed below the control-bank wiper, but this specific wiper is found only on a special-purpose switch, such as a linefinder. In the linefinder equipment, this wiper searches for a marked level on the vertical bank. The vertical-bank wiper moves outward away from the vertical bank following the first rotary step. This vertical-bank wiper differs from the other wipers in that it has only one lip and it is mounted perpendicular to the shaft rather than horizontal. The line-bank wipers are shown near the loop of the wiper cords. Their construction is identical to the control-bank wipers.

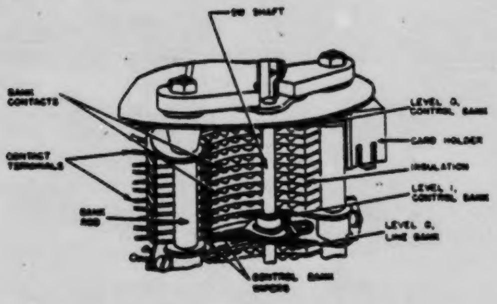


Figure 2-7. Strowger switch contact bank assembly.

Some Strowger stepping switches have two line-bank wipers rather than only the one as figure 2-6 shows. The control-bank and line-bank wipers are placed on the shaft with their home position being one step below the associated bank of contacts and one step to the left of the first set of contacts in the first level. The control-bank wipers are mounted to operate in unison with the line-bank wipers. When the line-bank wipers are elevated to a specific level (row) of bank contacts in the lower bank of the bank assembly, the control wiper is raised to the corresponding row of contacts in the upper bank. In other words, if the switch steps five times, the line-bank wipers are positioned to rotate over the fifth row of contacts in the lowest bank; likewise, the control-bank wipers are positioned to rotate over the fifth row of contacts in the upper bank. Now, rotating the shaft one step permits the wiper lips to rest against the first contacts in the selected bank level. Additional rotations enable the wipers to test the subsequent contacts in the bank level.

NOTE: The wiper's terminology is derived from the bank assembly with which it functions.

Contact bank assembly. Figure 2-7 shows a partial view of a Strowger switch bank assembly. You can see the 10 control bank levels 1 through 0, but you have to assume that there are other banks below. Level 0 of a line bank is also identified. Each bank level is shaped in a semicircle and has 10 contacts or 10 pairs of contacts. The contacts are brass and they are separated by insulation. Each contact extends through the switch and then beyond the insulator for a short distance. This extended portion allows the conductors from lines, trunks, or other circuits to be terminated. The control-bank wipers of the two-motion switch of figure 2-7 have 100 points to test, since there are 10 levels with 10 contacts to each level. The contacts of this illustrated control bank are designated control (C), and they correspond to the sleeve (S) designation for a control lead in other equipment. A control bank may have 100 pairs of contacts; in this arrangement, the extra conductors are designated extra control (EC) or special control (SPL C).

In a line-bank level, the 10 contacts are paired, one contact placed above the other. The upper 10 contacts are called negative (−), and the lower 10 contacts are referred to as positive (+). These designations correspond to the ring (R) and tip (T) conductors in other equipment. Line banks terminate the cable pairs from telephone lines or trunks. Dialing and talking circuits are completed through the contacts of these banks.

Exercises (208):

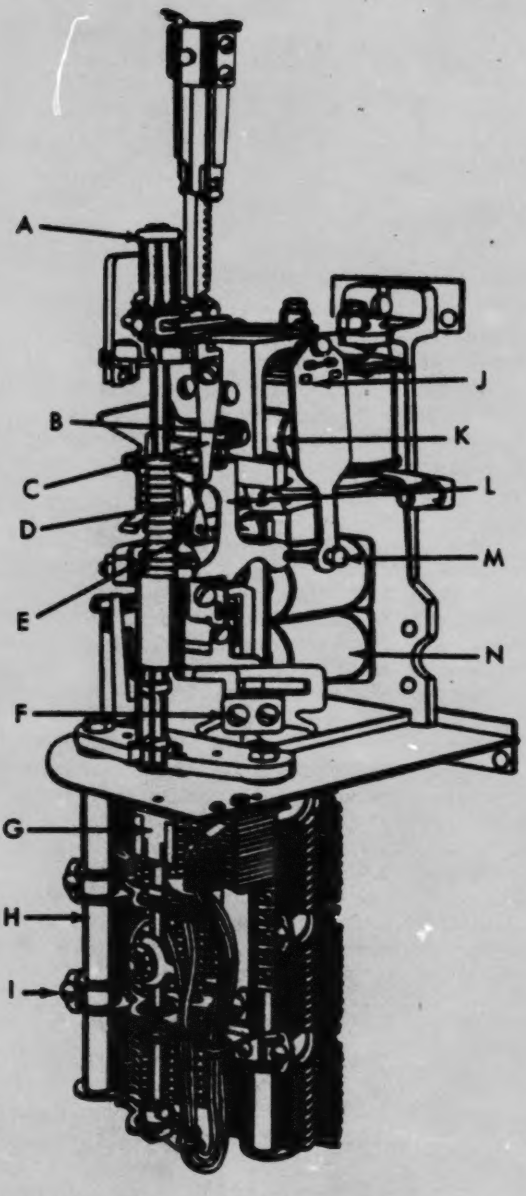


Figure 2-8. Strowger two-motion switch, half-left view (objective 208, exercises 1-9).

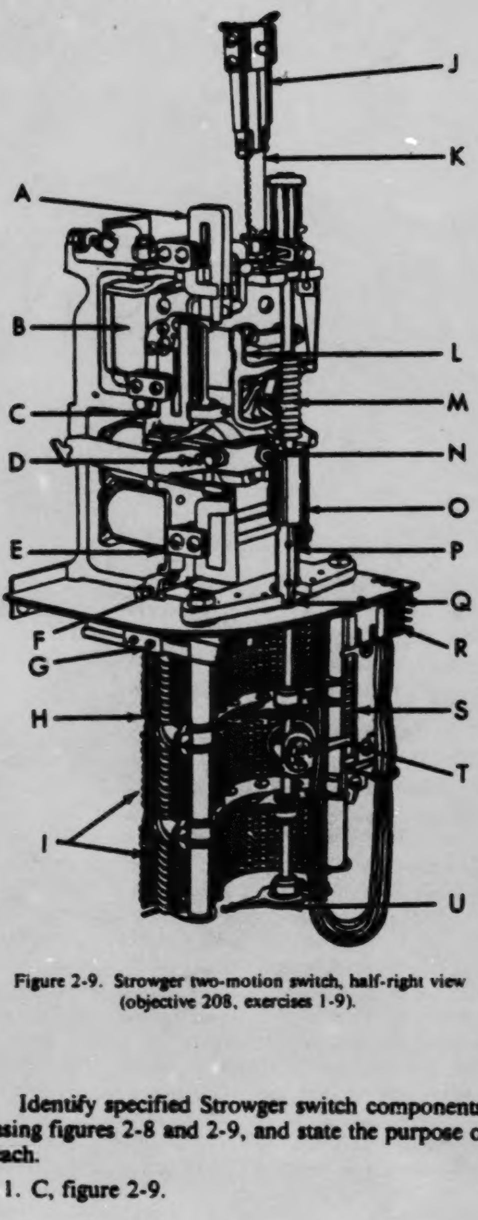


Figure 2-9. Strowger two-motion switch, half-right view (objective 208, exercises 1-9).

Identify specified Strowger switch components, using figures 2-8 and 2-9, and state the purpose of each.

1. C, figure 2-9.

2. M, figure 2-8.

3. B, figure 2-9.

4. A, figure 2-8.

5. L, figure 2-8.

6. L, figure 2-9.

7. A, figure 2-9.

8. E, figure 2-9.

9. D, figure 2-8.

209. Given statements describing switch adjustment problems, state what adjustment(s) need to be made and what tool(s) should be used for each adjustment.

The basic purpose of switch maintenance is trouble prevention rather than trouble clearance, since one switch in trouble may not affect a call through the central office. When it becomes necessary to perform preventive maintenance on a particular switch in your central office, the task, similar to relay maintenance, involves testing, adjusting (if necessary), and cleaning the switch. As long as a switch performs its function, we suggest that you make no attempt to adjust it. A switch will operate satisfactorily as long as it remains within its maximum allowable range of adjustment. Due to normal use, you should expect a switch to deviate some from its normal operating values. However, if you determine that a switch is out of its maximum alowable range of adjustment, naturally it must be adjusted.

Testing the Switch. The logical approach to switch maintenance is to first test the switch to determine if it is operating properly.

Adjusting the Switch. After you have tested a switch, you find that an electrical or mechanical adjustment is necessary. If the electrical adjustment pertains to the control relays of the switch, you should apply the principles of relay maintenance covered in Chapter 1. On the other hand, if the switch requires a mechanical adjustment, such as the vertical or rotary stepping mechanisms, you would have to refer to the manufacturer's specifications appropriate to that switch.

In order to learn the techniques of mechanically adjusting a switch, you must practice adjusting it.

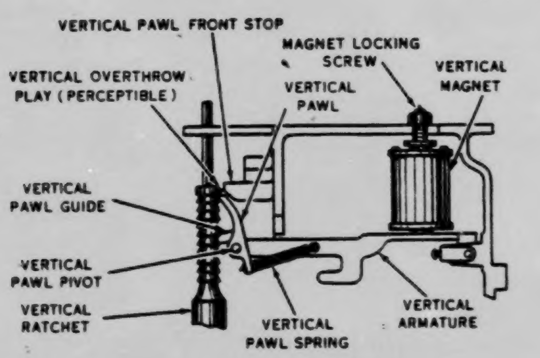


Figure 2-10. Vertical stepping mechanism.

As we did with relay adjustment, we will limit our discussion to the effects that the mechanical adjustment will have on the switch.

We will not illustrate a complete switch here. We will review the mechanical functions of the switch and illustrate the main parts of it which periodically need adjustment.

The two-motion Strowger stepping switch consists of a shaft, wipers, vertical and rotary magnets, cam, pawls, springs, etc., which comprise the stepping mechanism. When current is applied to the vertical magnet of the switch, an armature associated with the magnet presses a pawl against a tooth of the vertical ratchet on the switch shaft, thus raising the shaft one step. Let's stop right here and view the vertical stepping mechanism.

Vertical stepping mechanism. Notice in figure 2-10, the vertical stepping mechanism consists of the vertical magnet and its armature, the vertical pawl spring, vertical pawl, and ratchet.

What items should you consider concerning the adjustment of the vertical stepping mechanism? Actually just about everything you see in figure 2-10. Consider the vertical magnets. If the magnets are not positioned according to requirements set

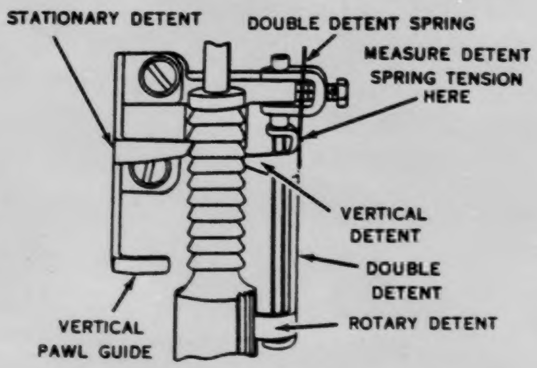


Figure 2-11. Vertical stepping mechanism.

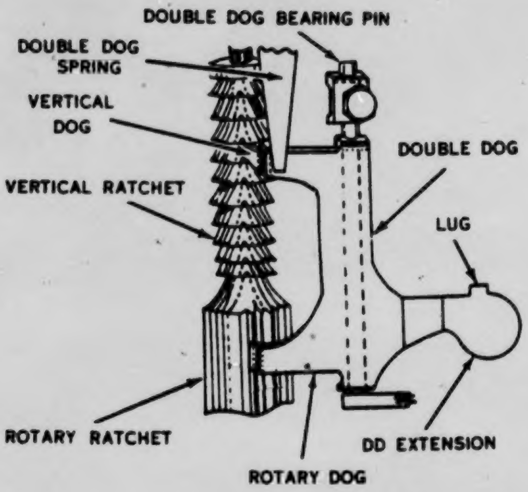


Figure 2-12. Vertical stepping mechanism.

forth in the manufacturer's specifications, the vertical play of the shaft will be affected. For example, the free vertical play of the shaft should be between 0.002 inch and 0.010 inch. If the vertical play is above 0.010 inch, the magnets should be raised. If the vertical play is below 0.005 inch, the vertical magnets should be lowered. In figure 2-10 notice the vertical armature. You can see that the vertical pawl, which engages the teeth of the vertical ratchet, is attached to it. If the vertical armature is out of alignment, the vertical pawl will also be out of alignment in relation to the vertical ratchet teeth. Since the requirement for smooth vertical stepping is to have the vertical pawl centered to the vertical shaft, you must, if the armature is out of adjustment, bend the armature either to the left or right to position the pawl so that it centers the vertical shaft.

Figure 2-11 shows a different view of the vertical stepping mechanism. It shows the vertical ratchet and associated double and stationary detent. The function of the double detent, often called double dog, is to prevent the shaft from restoring to normal when the switch is stepping in a vertical or rotary direction. The purpose of the stationary detent is to support the weight of the shaft during rotary stepping. Again referring to figure 2-11, the double dog consists of a vertical detent and rotary detent. During vertical stepping, the vertical detent rides over the flanks of the vertical teeth. The vertical detent will drop in under a vertical tooth just before the vertical armature has traveled its full distance, to prevent the shaft from returning to normal during vertical stepping. The rotary detent, during the course of vertical stepping, remains static in a groove of a rotary tooth. Figure 2-12 is another view of the vertical stepping mechanism. This view shows the double dog spring which holds the vertical dog in its proper place in relation to the vertical teeth while the shaft is raising. Also this view shows an extension to the double dog, which is associated with the release mechanism of the switch.

Now that we've explained the functions of the major items that make up the vertical stepping mechanism, let's briefly consider certain adjustments that periodically have to be made. With reference to figure 2-12, the vertical dog must have a certain clearance between its top surface and the underside of the vertical teeth when the switch is operated to keep the vertical overthrow of the shaft at a minimum. This insures smooth vertical stepping of the switch. If the vertical overthrow of the shaft is excessive, you must bend the vertical dog up to correct the problem. Notice the double dog spring in figure 2-12. Its purpose is to provide tension enough against the vertical detent so that the detent will not become disengaged from the vertical teeth during stepping. The tension on the spring is measured in grams, and approximately 250 to 400 grams' tension is required to secure the vertical detent. With reference to figure 2-12, notice the stationary detent. A groove is cut in the vertical ratchet and the stationary detent must be adjusted to pass through the groove when the shaft is being moved up or down. The stationary detent has no function with the vertical stepping. Its function, as mentioned previously, is to support the weight of the shaft during rotary stepping.

The rotary stepping of a two-motion stepping switch works essentially on the same order as the vertical stepping mechanisms. As a matter of fact, it has the same number of acting parts: rotary magnets, armature, pawl ratchet, and detents. These parts need periodic adjustment as does the vertical mechanism. However, since the rotary stepping function is similar to the vertical stepping function, we will not discuss the mechanism in terms of its adjustment; instead, let's take a look at and talk

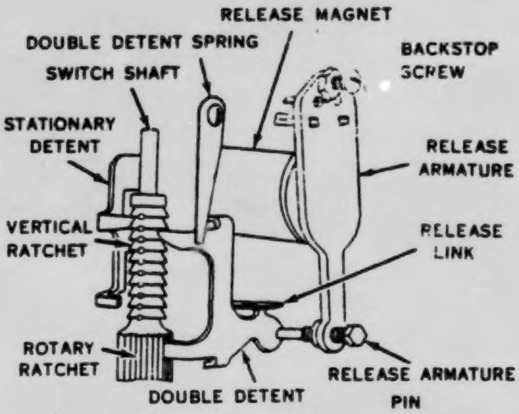


Figure 2-13. Release mechanism.

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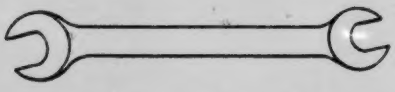
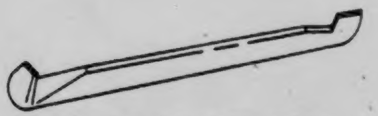
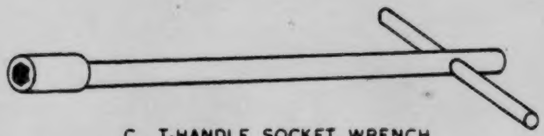


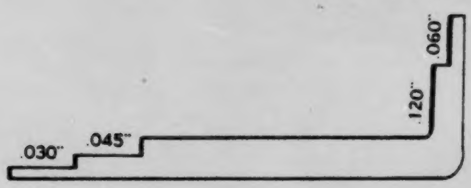
A OPEN END WRENCH



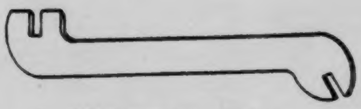
B OFF-SET SCREWDRIVER



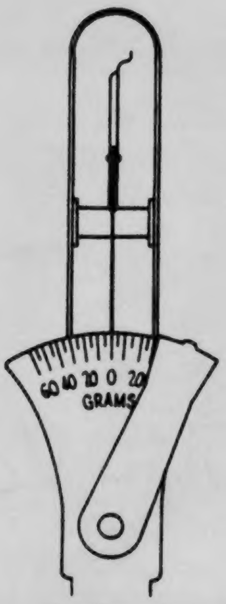
C T-HANDLE SOCKET WRENCH



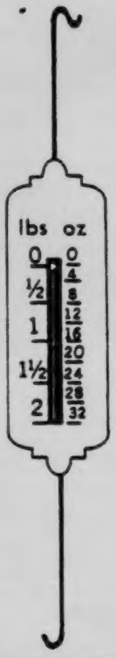
D L-GAGE



E DOUBLE DOG BENDER



F GRAM GAGE



G FISH SCALE

Figure 2-14. Switch adjusting tools.

about the release mechanism of a two-motion switch.

Release mechanism. Figure 2-13 pictures the release mechanism of a two-motion stepping switch. The release mechanism consists of a release magnet, release armature, release armature pin, and release link. The release mechanism operates to restore the switch to normal after the switch completes its vertical and rotary stepping. With reference to figure 2-13, the release magnet operates and attracts the release armature which, in turn, presses against the double detent. The double detent pivots, withdrawing the vertical and rotary detents from their respective ratchets of the shaft. The double dog (double detent) is not permitted to return to the ratchets because of the release link.

The adjustments required for the release mechanism are relatively simple. Periodically, the release armature stroke must be adjusted so that the striking pin of the armature presses the double dog with enough force to withdraw the double dog from the vertical and rotary ratchets after stepping. Also, the striking pin must be turned in or out so that the release link will drop over the lug of the double dog without binding.

Switch Cleaning. Good housekeeping is the most important single task required to keep your central office operating properly. Dust and dirt on the switch mechanism not only cause the switch to deteriorate, but can prevent its stepping. When it becomes necessary to clean the switch, the parts to consider are the banks, the control relays, and all accessible moving parts. As you'll recall, relay contacts can be cleaned with a piece of bond paper and the accessible moving parts can be cleaned with a lint-free cloth.

Adjusting Tools. Figure 2-14 pictures some of the more important tools used in adjusting the two-motion Strowger stepping switch:

a. Figure 2-14,A, shows an open-end wrench, which is used on magnet adjusting screws, adjusting caps, and locknuts.

b. Figure 2-14,B, pictures an offset screwdriver. It is used to turn screws positioned at an angle.

c. Figure 2-14,C, shows a T-handle socket wrench, which is used to turn screws holding the clamping brackets.

d. Figure 2-14,D, shows the L-gage. It is used to measure large clearances.

e. Figure 2-14,E, pictures the double dog bender. It is used to bend the double dog.

f. Figure 2-14,F, shows a gram gage. This tool is used to measure spring tension.

g. Figure 2-14,G, pictures a fish scale. This tool is used in place of the gram gage when springs require more tension than the gram gage can measure.

Exercises (209):

State what adjustment(s) need to be made and what tool(s) should be used for each adjustment, for the switch problems below.

1. The release magnet operates, but the switch fails to release.

2. The switch does not return completely to the left during release on all vertical levels.

3. When a linefinder switch steps to the 11th rotary step, the release magnet does not operate. It is not an electrical problem.

4. A linefinder oftentimes steps more vertical steps than it should; the vertical wiper is adjusted properly.

5. The release magnet remains operated after the switch is completely released.

210. State how selected switch adjustments affect other adjustments or switch actions.

Switch maintenance is one of the things you spend most of your time on. It is not really difficult and one of the things that makes it even easier is knowing how the various adjustments work together.

Switch Adjustment Relationships. Some of the obvious relationships are the wipers and the bank contacts, the normal pin and the off-normal lever. If the wipers are not lined up with the contacts of the bank, you have broken wipers and bank contact insulators. If the normal pin or off-normal lever are not properly adjusted the VONs cannot do their thing or the switch may not return to normal when released. Let's look at some of the others.

Vertical assembly. Think about all the parts involved with vertical stepping. Look at figures 2-10, 2-11, and 2-12. When the vertical magnets operate, the vertical armature pulls up, raising the pawl. The pawl engages the vertical ratchet and raises the shaft. The double dog's vertical detent slips under the ratchet to keep it from falling. Hold

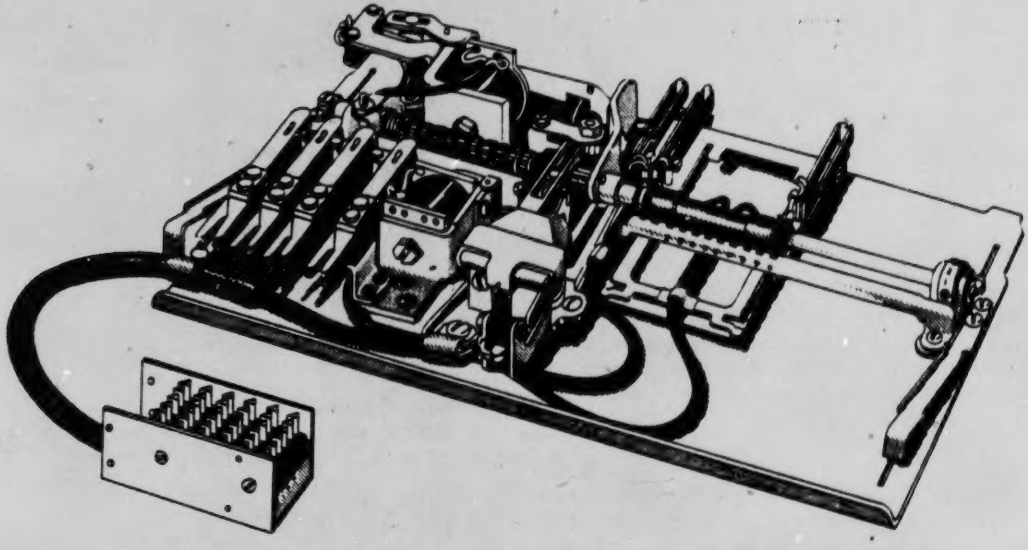


Figure 2-15. Universal two-motion switch.

on just a minute! What if the magnets do not raise the shaft high enough or raise it too high? What happens if the vertical pawl guide or vertical detent are not adjusted properly? There is more, but you get the picture. Instead of a smooth working switch, you could have a real headache.

Rotary assembly. Figures 2-1 and 2-4 show parts of the rotary stepping mechanism. If the rotary magnets pull the rotary armature too far, the switch oversteps—if it isn't pulled far enough, the switch cannot step rotary. If the rotary armature backstop or rotary pawl guide are not adjusted properly, rotary stepping may be bad or even nonexistent; to say nothing of the rotary pawls that may be broken.

Release assembly. Figure 2-5 shows the release mechanism components. If the release armature pin is out of adjustment, the switch might not release or it might cause the double detent spring to lose its tension due to moving too far from the shaft during release. If the release link is out of adjustment, the double detent may not disengage the shaft at normal. If the armature backstop screw is out of adjustment, the armature might not be pulled to the release magnet to release the switch.

We have not covered each item on the switch, but with a little thought and your knowledge of switch components and functions you can understand fully how one adjustment affects others.

Exercises (210):

State what switch actions and/or adjustments are affected by a change in the adjustments listed below. Use figures 2-1 through 2-13 as needed.

1. Stationary upper detent is raised.

2. Pawl guide is lowered.

3. Off-normal lever bent down.

4. Release armature pin screwed out.

5. Vertical magnets lowered.

6. Rotary magnets moved toward the back of the switch.

2-2. XY Switches

With the exception of the mechanical way it works, the XY Universal switch does the same things a Strowger two-motion switch does. However, its physical makeup and mechanical operation are considerably different from those of the Strowger switch.

In an XY office you find DECA switches, which equate to the minor switch in a Strowger office; rotary switches, which are almost identical to those in a Strowger office; and XY Universal switches.

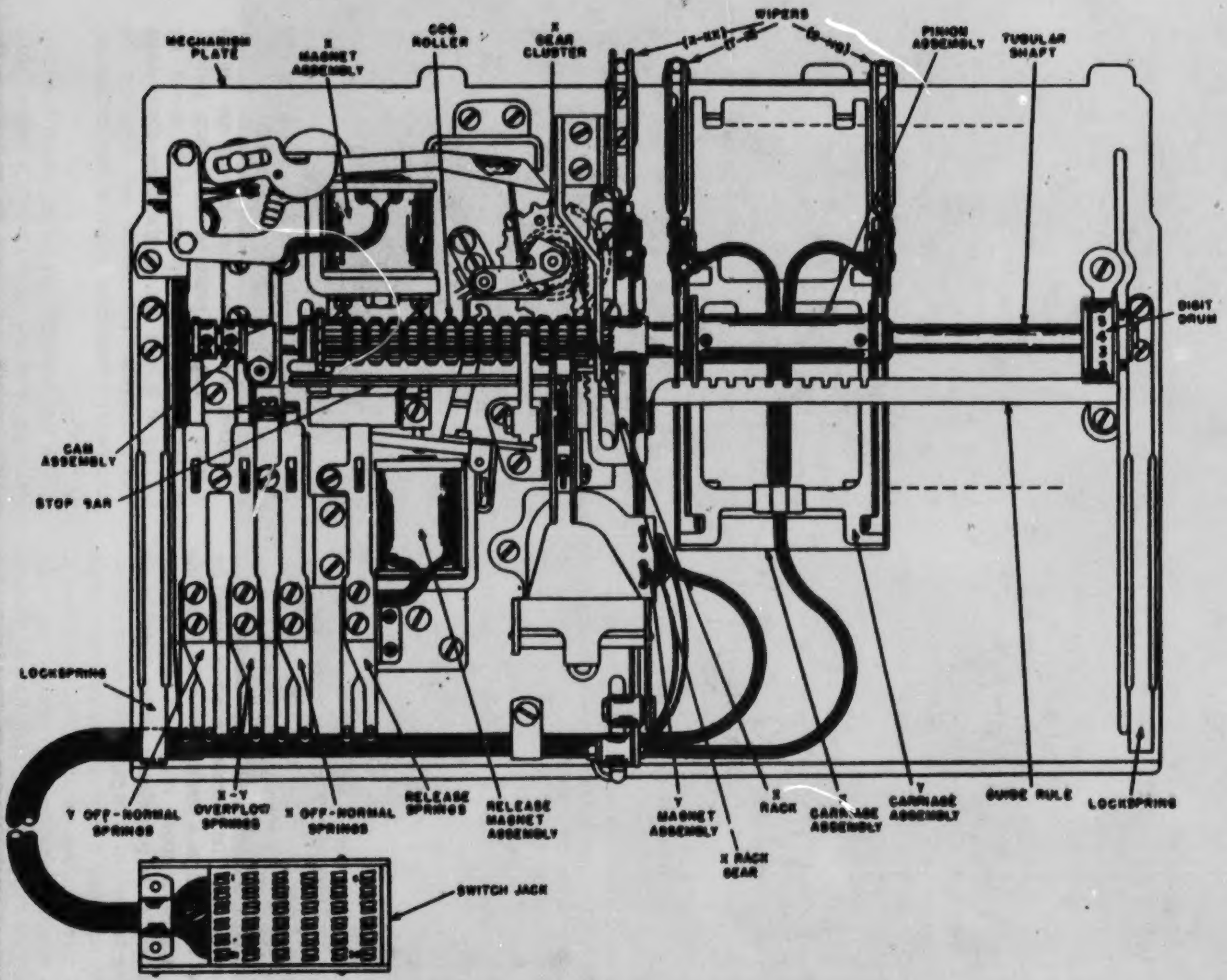


Figure 2-16. XY switch components.

In this section we deal only with the XY Universal switch. The truly unique thing about this switch is that it may be used as a linefinder, selector, or connector. It is not a part of any particular circuit until plugged into that circuit by means of the 36-point F plug attached to the switch cable.

211. From a picture of an XY switch, identify selected parts and state the function of each.

XY Universal Switch. Figure 2-15, pictures a universal stepping switch. The switch is so named because it is usable as a linefinder, selector, or connector without changing any components or making any adjustments. You can see in the illustration that the contact bank assembly is not a part of this switch. The control relays are also in a unit separate from the switch. The switch illustration shows a shaft, wipers, magnets, cogs, springs, etc., which provide the stepping action. The identification for these components will be found in figure 2-16. The method of making the connection differs from the procedure used in the Strowger switch. This switch uses two motions to connect to the chosen circuit of a group of 100 lines, but these motions are in a single horizontal plane. The switch is first stepped in the X direction and then in the Y direction. The designations X and Y are chosen from the rectangular coordinate system in which X corresponds to east and Y to north, as used on maps, hence the name "XY" switch. The first motion of the switch is always in the X (east) direction to move the T, R, S, and HS wipers and the X and Y carriages along the tubular shaft toward the digit drum. This drum is the device shown to the far right in figure 2-15. The marked 1 and 2 on it are within your view. After the necessary steps in the X direction are completed, the Y carriage steps north as many steps as necessary to place the T, R, S, and HS wipers in contact with the proper switch bank wires. The switch can move a maximum of 11 steps in the X direction or 11 steps in the Y direction. The 11th step identifies overtravel. The number of steps that are taken is determined by the control circuits.

X direction stepping takes place when the X magnet operates. The X armature moves toward the magnet core and, as a result, presses the X driving pawl against a tooth of the X gear ratchet. Consequently, the gear cluster rotates. Teeth of the rotating gear sprocket engage a cog roller ratchet, thereby activating it. The companion roller moves the X carriage along the shaft. Each operation of the X magnet moves the X carriage one step to the right on the switch shaft. A retaining pawl prevents the carriage from returning to the normal shaft position at the end of the step. The released X magnet permits the driving pawl to return to a position that is in line with the succeeding tooth of the X gear ratchet. After the X stepping is terminated, the control circuits prepare for the Y direction stepping.

Operating the Y magnet continues the stepping progression. The movement of the Y armature toward the Y magnet core results in the Y driving pawl engaging a tooth of the cog roller. The turning cog roller moves pinion gears which, in turn, carry the Y carriage and wipers toward the north (at a right angle to the shaft). Reduction of current in the Y magnet causes it to release. Accordingly, the armature restores and disengages the Y driving pawl from the cog roller. The Y driving pawl is prepared for the next step when it is in place beside a tooth of the cog roller. A retaining pawl prevents return of the Y carriage to the home position. An additional Y direction step is made during each operation of the Y magnet.

There is an additional important movement on this universal switch. A third wiper assembly is moved while the switch components are being stepped. The X-XX wipers attached to the X rack move in the Y direction only, but make this motion in unison with the X carriage as it steps in the X direction. The X gear cluster has a separate gear which drives the X rack in the Y direction at the same time another gear of the X gear cluster drives the cog roller and the attached assemblies in the X direction. The X-XX wipers accomplish special circuit switching for linefinder control and restricted or code call service.

The switch returns "home" after the release magnet operates. The operated release magnet pulls the release armature. The operated release armature presses the retaining pawls out of engagement with the roller and ratchet; thus they allow the Y and X carriages to restore.

This universal stepping switch, which is pictured in figure 2-15, has a steel baseplate. The plate is placed so that it is horizontal to the exchange floor and, similarly, the components which enable the switch to be functional lie horizontal to the steel plate. The terminology for these components conforms to the terminology used to identify units in the previous stepping switches. Included in the switch, then, is the stepping mechanism.

Stepping mechanism. The stepping mechanism consists of magnets, gears, pawls, ratchets, springs, etc. Figure 2-16 is a top view of the switch. By looking at it, you can see the many components which comprise the switch and visualize the component arrangement which allows mechanical movement.

The cam assembly, cog roller, pinion assembly, and digit drum are supported by a tubular shaft which extends from west to east across the mechanism baseplate. The cam assembly operates the Y off-normal and the XY overflow springs. You can see these cams fastened at the west end of the shaft.

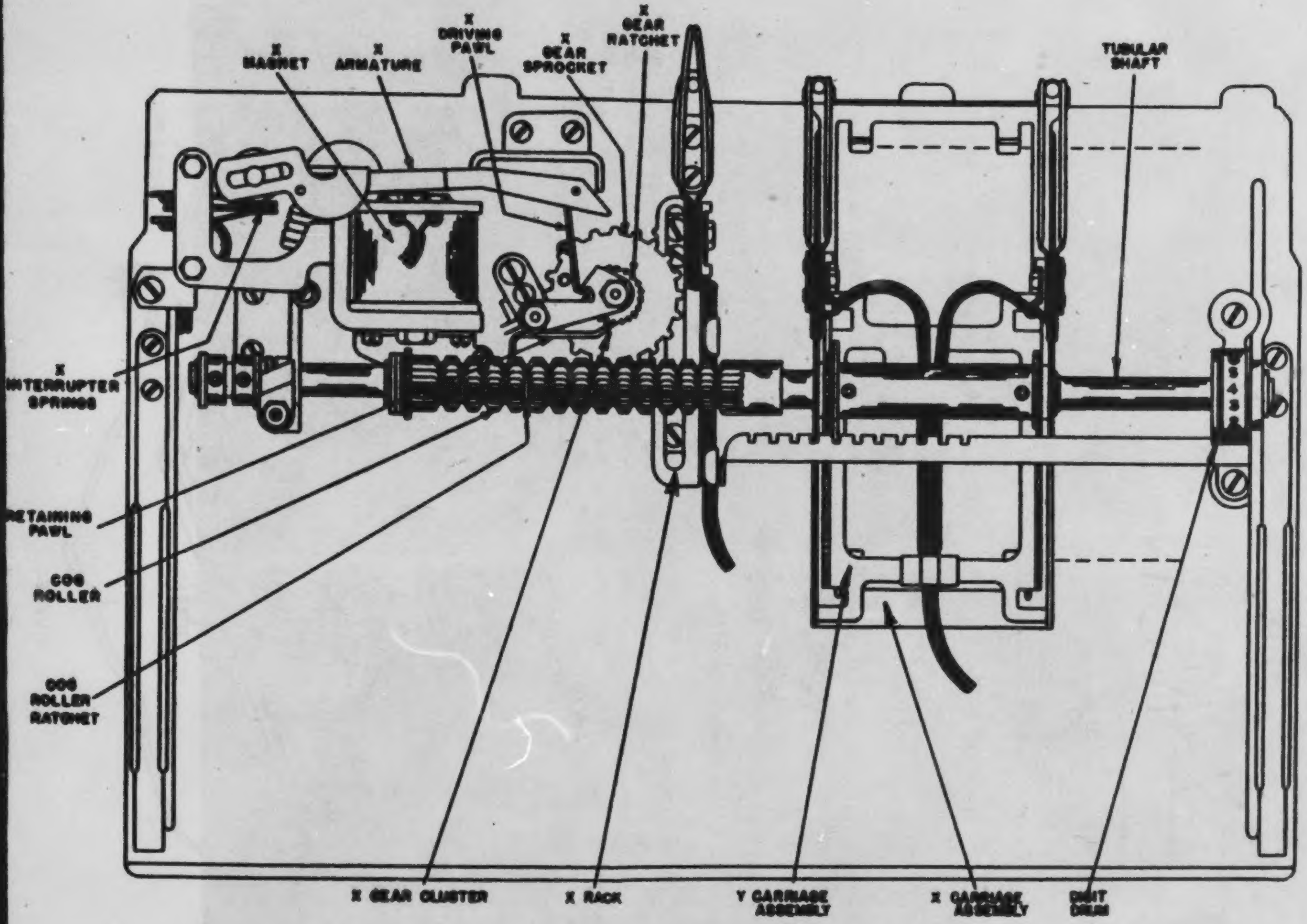


Figure 2-17. Switch stepped in X direction, simplified diagram.

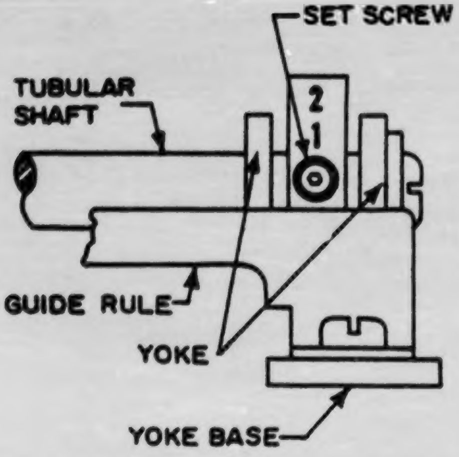


Figure 2-18. Digit drum in normal position.

The cog roller moves toward the digit drum (in the X direction) in response to the rotating X gear cluster. Figure 2-17 reveals a more simplified view of the X gear and cog roller relationship. At the same time that the cog roller moves toward the east, the X rack moves in the Y direction (north) as a result of the X rack gear movement. Figure 2-16 identifies the X rack gear, and figure 2-17 shows the X carriage assembly stepped to the fourth position. The X-XX wipers extend from the X rack; consequently, they are positioned against wires of the X-XX wire bank by the X rack gear. The X rack moves one step in the Y direction for each step that the cog roller moves in the X direction. The X rack is stepped only when the switch mechanism moves in the X direction. The cog roller rotates in the Y direction under control of the Y magnet assembly. The rotating cog roller positions the T-R and S-HS wipers in their respective wire banks.

The pinion assembly is supported by the X carriage assembly and is mounted on the tubular shaft. The teeth of the pinion gear engage teeth of the Y carriage assembly to move the T-R and S-HS wipers toward the wire bank. The pinion assembly rotates following the operation of the Y magnet. The pinion gears return to normal and likewise return the Y carriage to its home position following the operation of the release magnet.

The numbers on the digit drum indicate the position of the pinion assembly and thus show the Y position of the T-R and S-HS wipers in the wire bank. Figure 2-17 shows the top view of these numbers. The digit drum is locked to the shaft by a setscrew. On the older model XY switches, the setscrew is visible just above the guide rule when the switch is in its unoperated position (see fig. 2-18). On later models of the XY switch, the setscrew is located behind the guide rule when the switch is not operated. When the numbers on the digit drum are in the position shown in figure 2-18, it indicates that the Y carriage is in the home position. Operating the Y magnet twice would rotate the drum until the 2 is visible just above the guide rule and the 1 is behind the guide rule; therefore, the 1 would not be visible. The drum in figure 2-17 indicates no Y direction steps although, looking from this top view, it may appear that two steps have been taken. When 11 steps have been taken in the Y

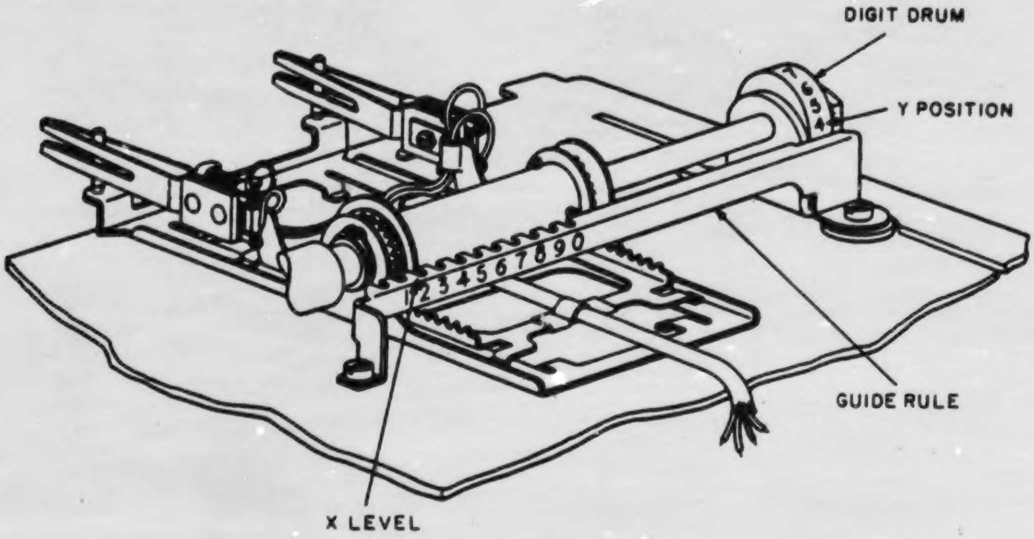


Figure 2-19. XY switch in position 24.

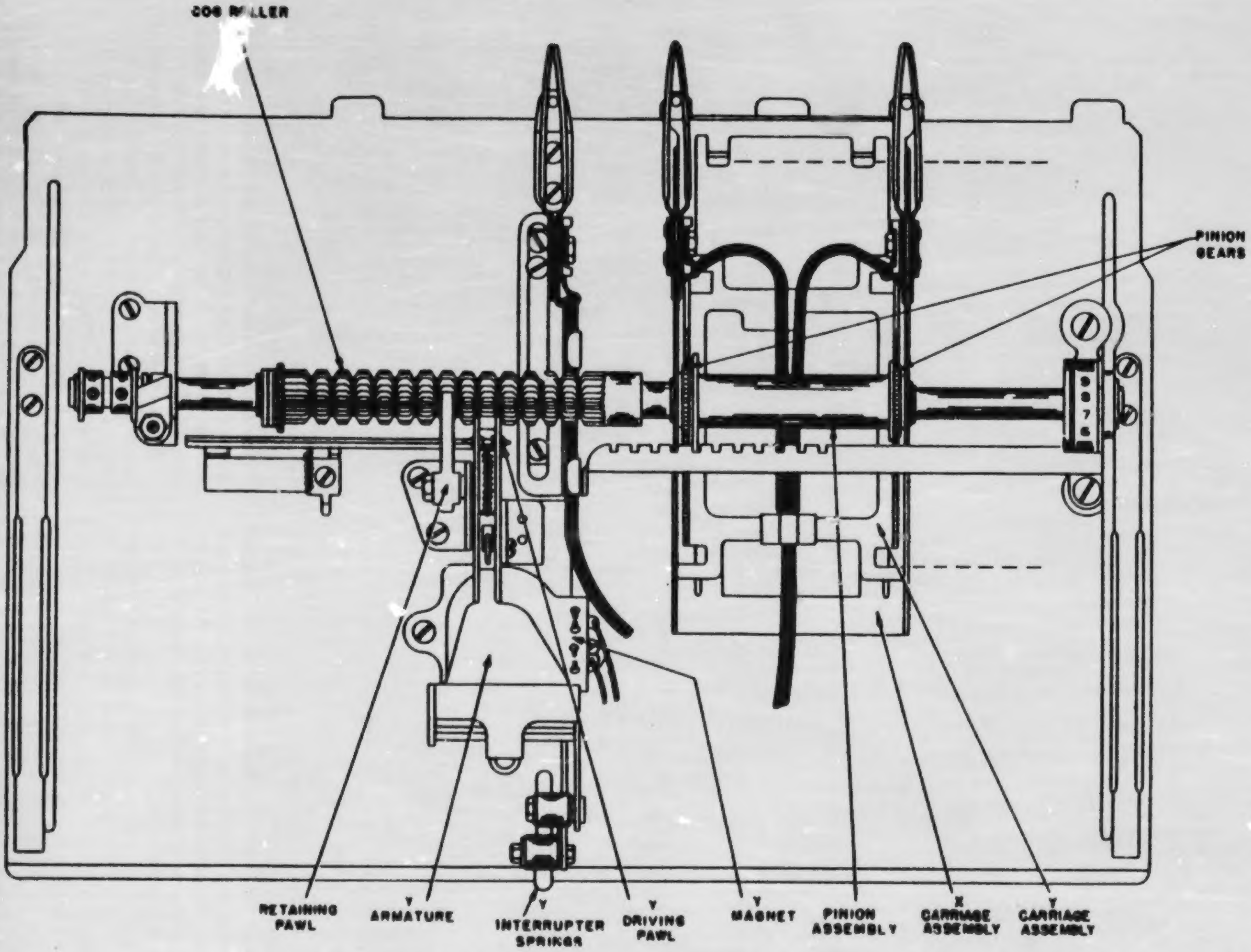


Figure 2-20. Switch stepped in X and Y position simplified diagram.

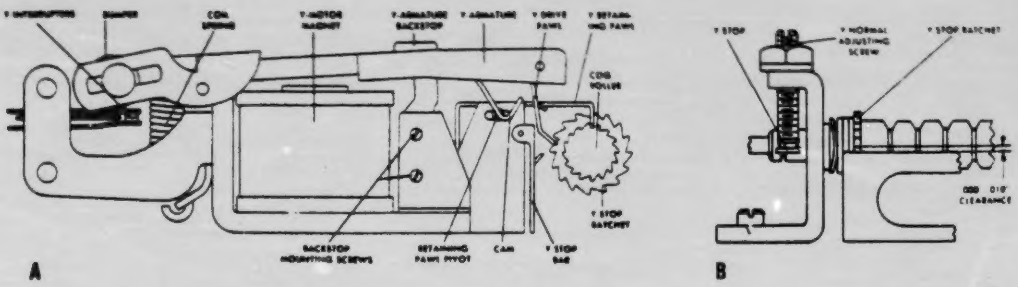


Figure 2-21. XY switch mechanism.

direction, no number is visible on the digit drum just above the guide rule.

The guide rule has numbers stamped on its face to indicate the number of steps taken by the switch in the X direction (fig. 2-19). This figure shows the X stepping mechanism as having stepped twice, and the Y stepping mechanism as having stepped four times. The switch position, in this case, is referred to as position 24. The guide rule numbers, as well as the digit drum numbers, are seen if the switch cover is removed for inspection.

The X carriage assembly moves only in the X direction to position the Y carriage, which is mounted on the X carriage, at the proper point for it to insert the T-R and S-HS wipers into the wire bank. The operated X magnet causes the X armature to move the X driving pawl. The operated X driving pawl engages a tooth of the X gear ratchet, thus moving the cog roller and the X carriage along the shaft in the X direction. An X return spring, not shown in figure 2-17, is tensioned during this action so that the components can be returned to the home position following release of the switch. A retaining pawl fits against the tooth of the X gear ratchet to prevent its return to normal at the end of each step. Release of the X magnet at the end of a current pulse causes the X driving pawl to be withdrawn from the ratchet and to line up in relation to the next tooth of the X gear ratchet. This same sequence of actions is repeated for each step taken in the X direction. Completion of the X direction stepping allows the control equipment to prepare circuits for stepping the Y direction mechanism.

The Y carriage assembly moves the attached wipers in the Y direction toward the wire bank. The operated Y magnet attracts the Y armature. Figure 2-20 identifies this Y armature and the remainder of the Y direction stepping mechanism. The operated Y armature actuates the Y driving pawl, which rotates the cog roller. The turning cog roller moves the pinion gears which, in turn, carry the Y carriage to the north. The retaining pawl presses against a tooth of the cog roller to prevent the return of the assembly until after the switch release. The released Y magnet allows the Y driving pawl to withdraw from the cog roller and to position beside the next tooth of the cog roller. Each additional operation of the Y magnet provides the same sequence of motions to step the Y carriage. After the required Y direction steps are taken, the control equipment opens the operating circuit of the Y magnet.

Figure 2-16 identifies the stop bar. Figure 2-21 illustrates this device and its associated components more clearly. Figure 2-21 shows a side view of the components; whereas figure 2-21 is a top view. The Y stop bar is pressed against a tooth of the Y stop ratchet by the operated Y armature. This stop bar limits the cog roller to one step with each operation of the Y magnet. Releasing the Y armature also restores the Y stop bar. To understand the need for this stop bar action, one must realize that the universal switch can make as many as 40 steps per second. The momentum of the rotating parts must be kept under control to obtain accurate stepping.

The release magnet has extended arms that disengage the retaining pawls from the X gear ratchet and the cog roller. The control equipment completes the operating circuit of the release magnet, which operates the release armature. Figure 2-22 identifies the release components of the universal switch and pictures the release of the X retaining pawl from the X gear ratchet. The Y carriage in this figure appears to be at normal, and the cog roller and X carriage assembly are within approximately one step of the home position.

Related components. The wipers are a necessary part of the switch but cannot be considered a part of the stepping mechanism. These wipers are constructed of nickel silver and are formed into twin contacts. They are under sufficient pressure to insure positive contact with the smooth, round, vertical wires of the wire bank. Figure 2-19 reveals the arrangement of these wipers and the peg that separates them. Each wiper is connected to a switch jack or plug by a conductor. Figure 2-16 pictures the cables, which include the conductors leading

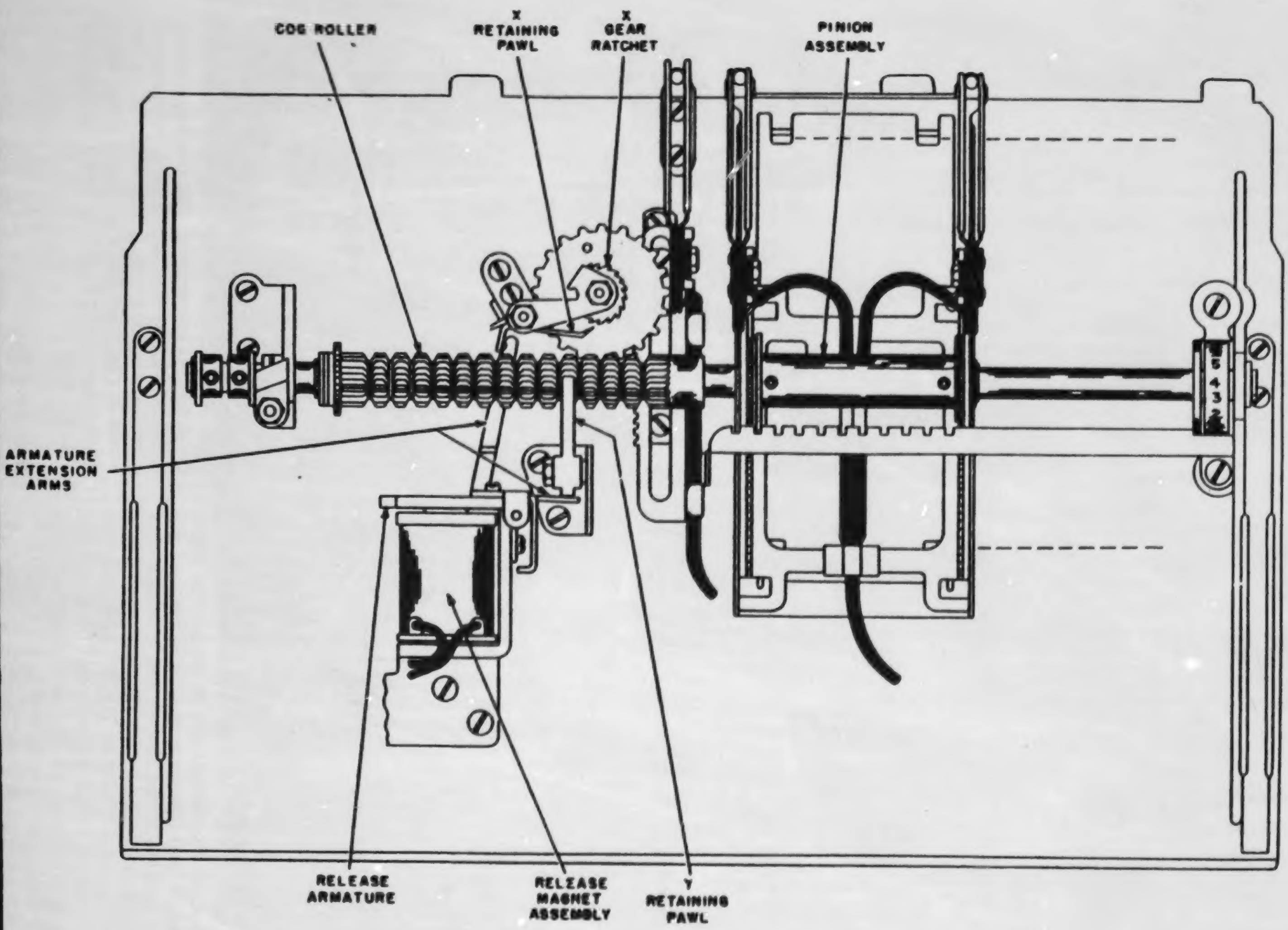
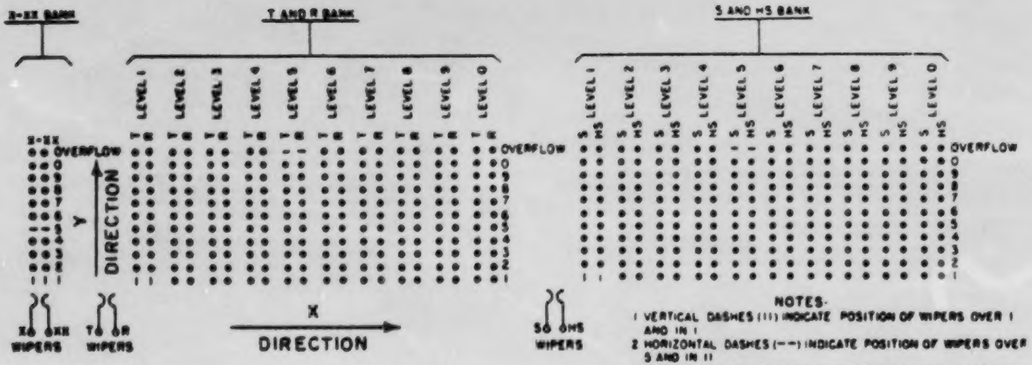


Figure 2-22. Release components.



NOTES:
1 VERTICAL DASHES (||) INDICATE POSITION OF WIPERS OVER 1 AND IN 1
2 HORIZONTAL DASHES (— —) INDICATE POSITION OF WIPERS OVER 5 AND IN 11
3 ASTERISKS (* *) INDICATE POSITION OF WIPERS OVER 10 AND IN 10.

Figure 2-23. XY switch bank, viewed from above.

from these wipers, and identifies a switch jack which terminates them.

Four spring assemblies provide control for the stepping and release of the switch. The X off-normal springs operate when the X carriage takes the first step, and the Y off-normal springs operate following the first step of the Y carriage. The XY overflow springs operate whenever the switch takes the 11th step in either the X or Y direction. The release springs operate at completion of the call to prevent switch seizure until it has returned to normal.

Additional spring assemblies which allow the call to progress are the X magnet interrupter and the Y magnet interrupter springs. The X interrupter springs open each time the X armature operates; they are necessary if a switch is to be functional in searching, such as in linefinding. The Y interrupter springs open during the Y armature movement and allow a switch to function automatically, such as in the Y direction stepping by the selector.

The wire banks are not a part of the universal switch, but if we are to understand the circuit connecting procedure and trace the circuits, it is necessary that we understand their design and placement. Figure 2-23 illustrates the wires within the bank, as they would appear from the top. You can see 11 dots to a row and 42 rows, which is a total of 462 possible connecting points. Each dot represents a wire contact which terminates a conductor. The wire contacts of the first row in the T and R bank terminate tip conductors, and the wire contacts of the second row terminate ring conductors. Together, these first two rows make a level. Rows 3 and 4 in the T and R bank make the second level; rows 5 and 6 in the T and R bank make the third level, etc. The same pattern is true in the S and HS bank, since level 1 includes the first two rows of wire conductors, level 2 includes the second two rows of wire conductors, etc. The only difference in the banks is the row designation—T and R for the west bank and S and HS for the east bank. These levels identify the X direction steps; for instance, the first operation of the X magnet moves the cog roller one step to the east. Accordingly, the T and R wipers and the S and HS wipers move to the inline position with level 1 wire contacts. (Fig. 2-23 identifies three pairs of wipers in the home position, but for now we are discussing just the two—T and R, and S and HS—pairs.) If a second X direction step is taken before the release magnet operates, the X carriage moves the T and R and the S and HS wipers in line with level 2 wire contacts. The numbers that appear to the right of each bank indicate the Y direction steps; for example, having moved the X carriage one step to the east and the Y carriage one step to the north, the T and R wipers would rest against the first wire contacts in level 1 of the T and R bank, and the S and HS wipers would touch the first wire contacts in level 1 of the S and HS bank.

NOTE: Vertical dashes are drawn to represent these connections in figure 2-23. The X-XX wipers are likewise touching the first wire contacts in the X-XX bank after the first X magnet operation. Ten X direction steps allow the X-XX wipers to press against the wire contacts marked with an asterisk (*) in the X-XX wire bank. Then, operating the Y magnet 10 times causes the T and R and the S and HS wipers to step to the 0 level 0 wire contacts (also marked with an asterisk).

The designation "overflow" indicates the wire contact which is connected to a potential so that a signal will notify the switchroom personnel when the switch has overstepped. This condition results when the stepping mechanism takes more than 10 steps. The horizontal dashes(- -) in the X-XX, the T and R, and S and HS banks indicate that the X carriage was moved 5 steps and the Y carriage was moved 11 steps.

Exercises (211):

Identify specified switch parts in figure 2-24 and state their function.

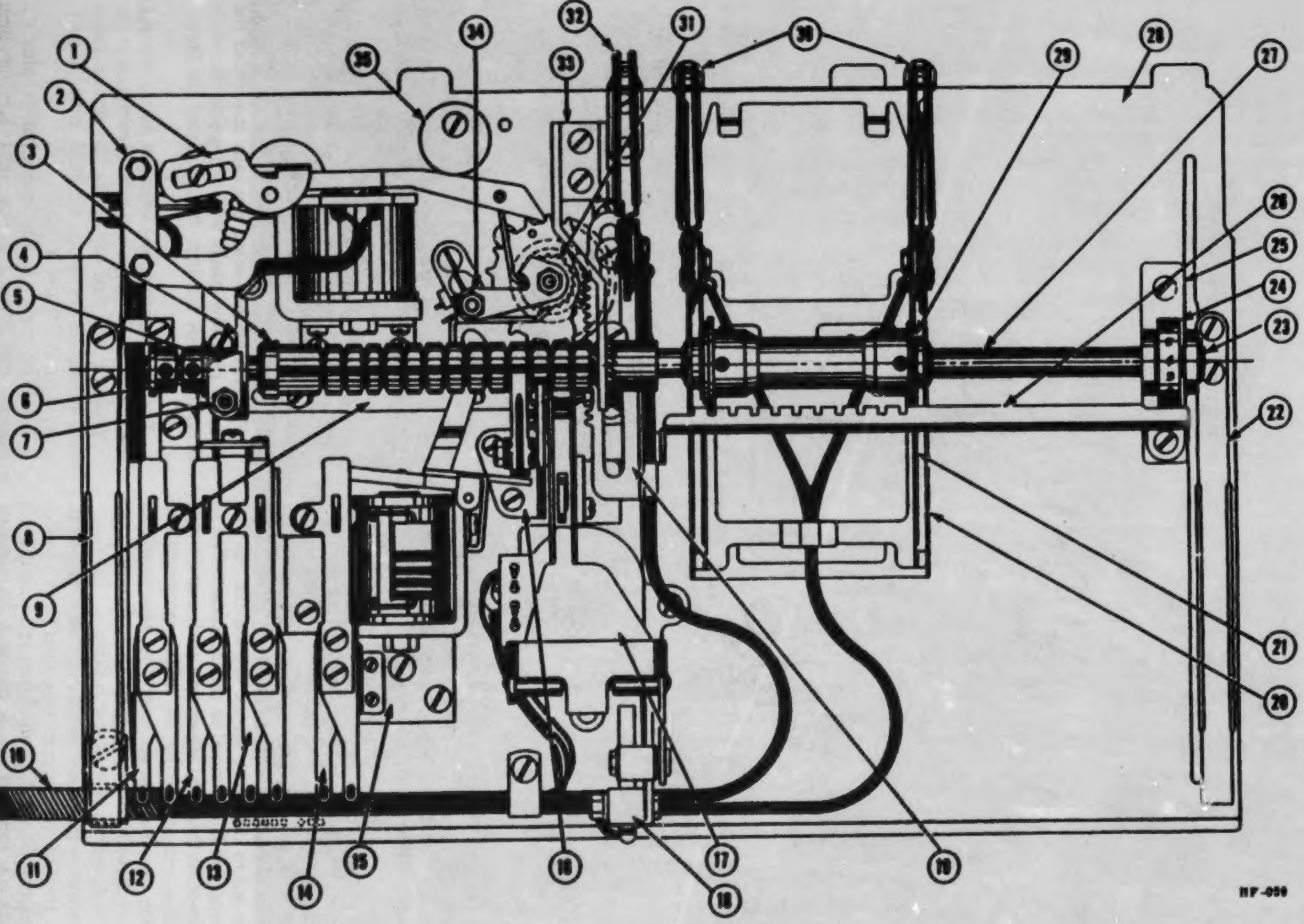


Figure 2-24. XY universal switch (objective 211, exercises 1-8).

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1. 8.
2. 24.
3. 17.
4. 26.
5. 35.
6. 15.
7. 27.
8. 1.

212. Given statements describing switch adjustment problems, state what adjustment(s) need to be made and what tool(s) should be used for each adjustment.

Switch adjustment in the XY system, while just as important as in a Strowger office, is considerably different. In this section we look at some of the major areas of adjustment, adjustment specifications, and tools used. This coverage is not intended to deal with all the adjustments, as that information is contained in the technical order.

Switches that need adjustment are found through routine testing (PMIs) or testing accomplished during troubleshooting. After you have found an out-of-adjustment switch, there are some basic tools and test equipment that you require.

Switch Adjustment Tools and Test Equipment. The piece of test equipment required for XY switch adjustment is the XY switch test set, figure 2-25. The tools required are a common screwdriver, spudger, wrenches and/or nut drivers, and possibly feeler gages; most measurements can be gaged by eye, however.

XY Switch Test Set. The proper use and interpretation of your XY switch portable test set will be a great asset in the routining and adjusting the XY switches in your office. Listed below and in their proper sequence are test, checks, indications of failures, and adjustments to be made. See figure 2-25.

Preliminary instructions. The preliminary instructions are outlined below:

(1) Before connecting the terminals to DC power, all keys on the test unit must be in their upright position and with toggle ON-OFF switch in the OFF position.

(2) DC power must be properly connected to the test unit.

(3) The XY switch to be tested must be in the HOME-NORMAL position before you insert it into the cell bank. The switch must be firmly seated in the cell bank and the "F" jack must be locked with corresponding male plug terminals.

With all of the above done, you are ready to start.

Spring pileup lamp check (fig. 2-25). The test set is arranged so that the four spring combinations can be quickly checked for spring contact and electrical continuity. In the tests and procedures outlined below, the following lamps light for proper operation:

(1) ON-OFF switch to ON. All keys at normal (UPRIGHT position). Four white lamps lighted.

(2) Move switch manually one step in the X direction:

a. White X-ON lamp out—Red X-ON lamp on.

b. White Release lamp out—Red Release lamp on.

(3) Move switch manually one step in the Y direction:

a. White Y-ON lamp out—Red Y-ON lamp on.

b. White Release lamp out—Red Release lamp on.

NOTE: With the switch being moved manually into the X or Y direction, operation of the Release Magnet (electrically) at this time is an indication that a Release path circuit from contacts 3 and 4 of the OFF Normal contacts to the Z magnet is complete.

(4) Moving the switch manually into either the X or Y overflow banks will extinguish the white overflow lamps and light the associated red lamp.

The test unit provides a source of pulses to check the Percent Make (high and low) capabilities of the XY switch. The first key on the left acts as a start key, the second key selects the cycle, either X-only, Y-only, or X-10 and Y-10:

(1) With the cycle key at normal (X plus Y), operate the Percent Make Start Key to high position. The switch should step positively to X-10 plus Y-10 without stuttering, locking, or skipping, and release. Recycle at least three times.

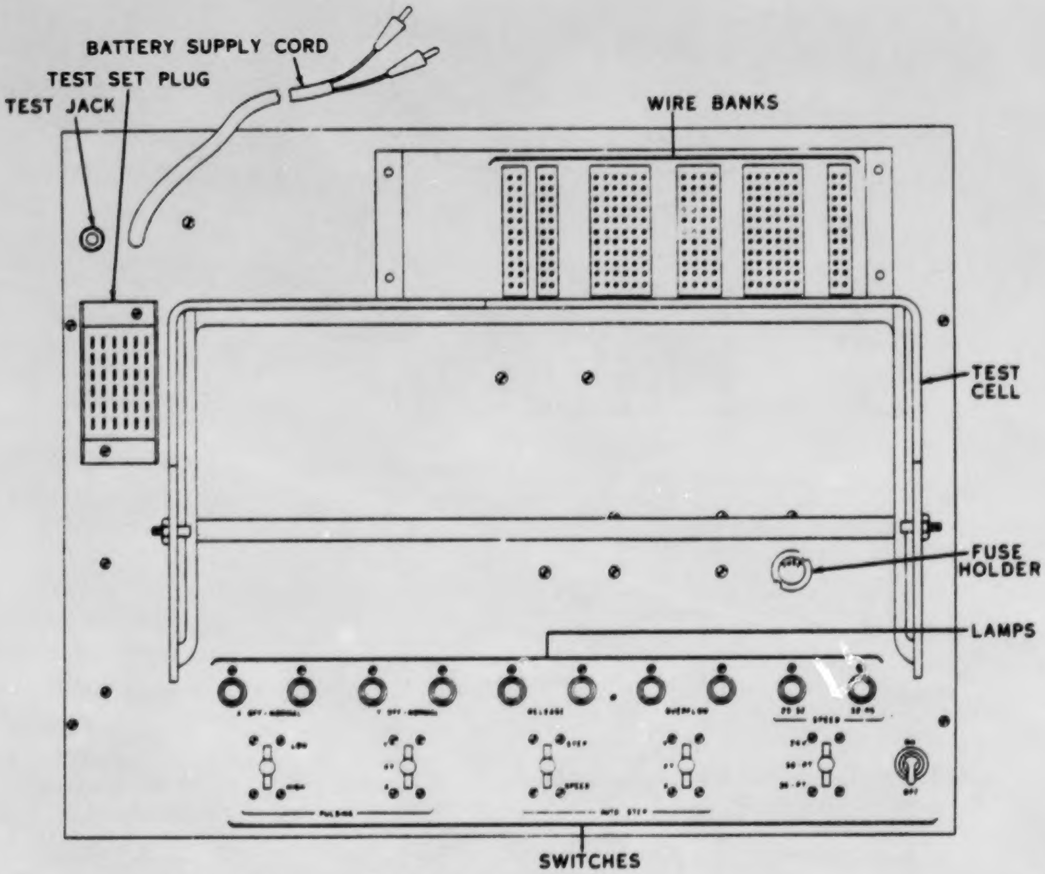


Figure 2-25. XY switch test set.

(2) Repeat as above, except with the Percent Make Start Key set on the LOW position.

Automatic stepping tests. The test unit provides circuits for operating the XY switch pulse assist in the X plus Y directions with automatic release and recycle. The fourth key selects the cycle ("Y" forward, "X" backward, or "X" and "Y" center). The third key acts as a start key which is moved forward to start the cycle. The first test to be made is to recycle from the X plus Y position at least ten times; later, run "X" and then "Y" separately. The switch should step out to X-10 plus Y-10 without stuttering, buzzing, or locking. Initial start of this action and continuous performance is controlled by normally closed interrupter X contacts and their associated interrupter leads.

NOTE: Operation of the signal lamps testing the overflow contacts shall be observed during the automatic stepping test while running *X or Y only.*

Speed test. The test unit will check the automatic stepping speed of the X-Y switch. However, the speed test can be made only with the switch moving in one direction (either X or Y). The fourth key selects the cycle and the third key serves as the start key when pressed backward and held in that position (NONLOCK KEY). The switch will move to the overflow position and remain there until the key is restored to normal. Speed indication is given through the lighting of green lamps.

The speed lamp requirements are these:

a. X-Direction—25 to 45 steps per second.
b. Y-Direction—32 to 45 steps per second.

If neither green lamp lights, the speed is in excess of 45 steps per second. If the 32-45 lamp lights, the speed is 32 to 45 steps per second. If the 32 to 45 lamp flashes and the 25-32 lamp lights, the speed is 25 to 32 steps per second. If both lamps flash and go out, the speed is below 25 steps per second.

NOTE: If the test unit is unable to give a proper speed check (no lamps lighting) for any one given direction, check the contact pressures on springs 6 and 7 of the associated off-normal pileup.

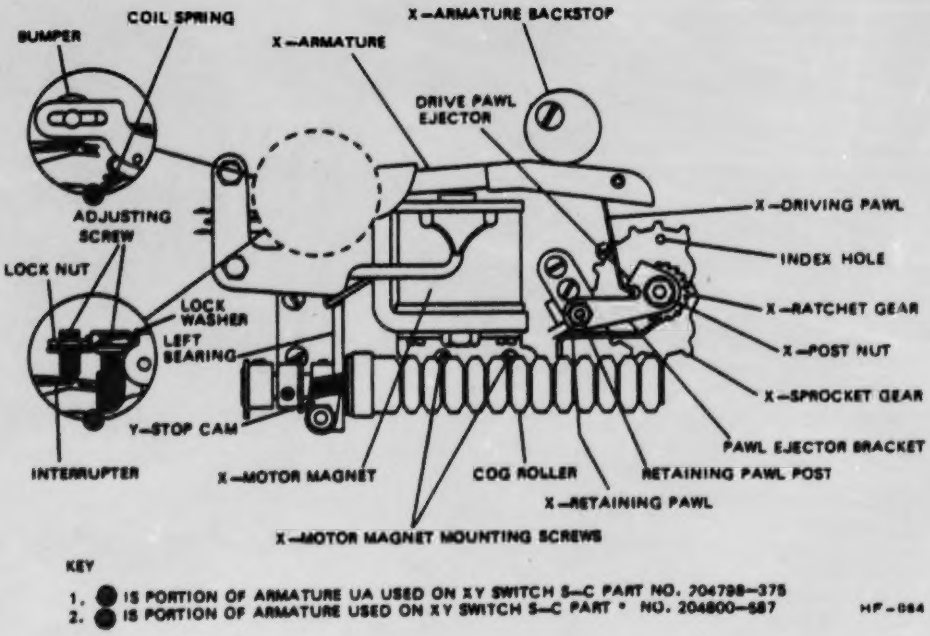


Figure 2-26. X-stepping mechanism, top view.

Wiper test. The circuits of the test unit are arranged to give an all-through electrical test for continuity and shorts:

(1) Wiper continuity check:

a. If either XX or X wiper fails to make proper physical contact with its associated wire bank or fails to complete an electrical circuit through the associated wipers and wire bank, the switch will move onto the X-overflow position and will not restore.

b. If any one of the tip, ring, sleeve, and HS wipers fail to make physical contact with their associated wire banks or fail to complete an electrical circuit through the wipers and their respective banks, the switch will move onto the Y overflow position and will fail to restore and recycle.

(2) Shorted wipers:

a. XX and X wiper shorted, the switch will not step in X direction.

b. T and R shorted, the switch will step to X-10 and Y-5 and recycle.

c. S and HS shorted, the switch will step to X-10, Y-1, and recycle.

Review of Operation. In order to make adjustments you must be able to interpret adjustment specifications, know how the switch works mechanically, and have the mechanical ability.

We discuss a few specifications but spend most of our time on reviewing how the switch works mechanically.

Stepping in the X direction. Figure 2-26 shows a top view of the X stepping mechanism. When the X stepping magnet operates, the X driving pawl engages the X ratchet gear. As the armature continues its travel, the X sprocket gear is rotated so as to move the cog roller one step in the X direction.

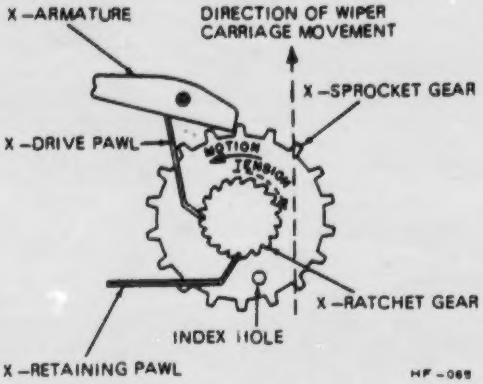


Figure 2-27. X-drive mechanism with X-magnet full operated.

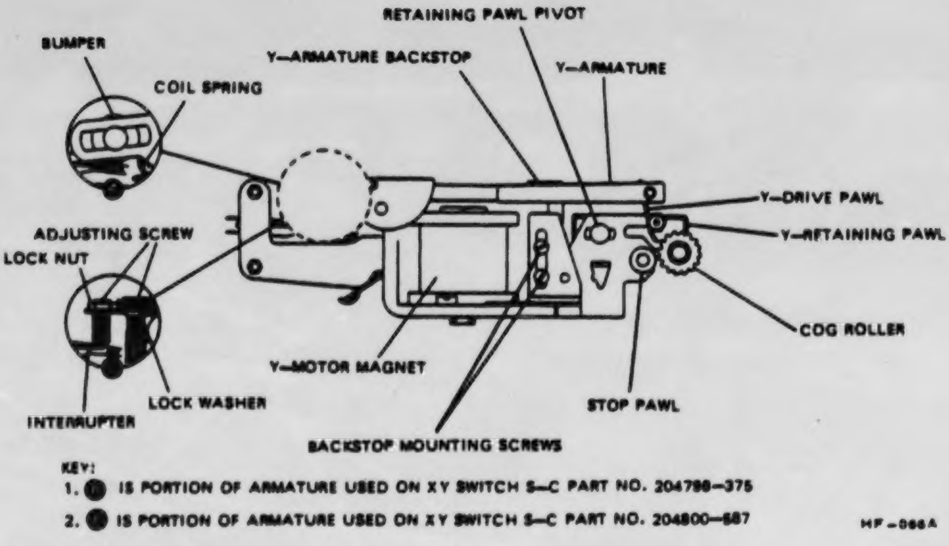


Figure 2-28. Y-stepping mechanism, side view.

The X retaining pawl then engages the next tooth of the X ratchet gear to prevent the X sprocket gear from returning to its home position. Back pressure on the X sprocket gear is supplied by a coil spring (not shown) mounted below the gear.

A gear mounted below the X sprocket gear is continuously engaged with the XX-X rack, figure 2-17, so that the rack is moved whenever the X gear cluster is rotated. Thus, the XX-X rack is advanced one step in the Y direction.

It should be recognized that the momentum of the switch, if not arrested, would carry each step beyond its limits. This is more easily realized when you consider that the stepping speed is often as high as 40 steps per second. In order to stop the X motion of each step, the end of the X armature engages a tooth of the sprocket at the bottom point of the armature travel. See figure 2-27.

The X interrupter springs are mounted on the rear of the X stepping mechanism, figure 2-17. Each time the X magnet operates, the X armature is pulled toward the magnet, raising the bumper so that it relieves the pressure on the upper X interrupter springs, figure 2-26.

Stepping in the Y direction. Figure 2-28 shows a side view of the Y stepping mechanism. By means of tension supplied by the drive pawl spring, the drive pawl always rides against the cam mounted below the Y armature. Figure 2-29, view A, shows the position of the drive mechanism when the Y magnet is fully restored.

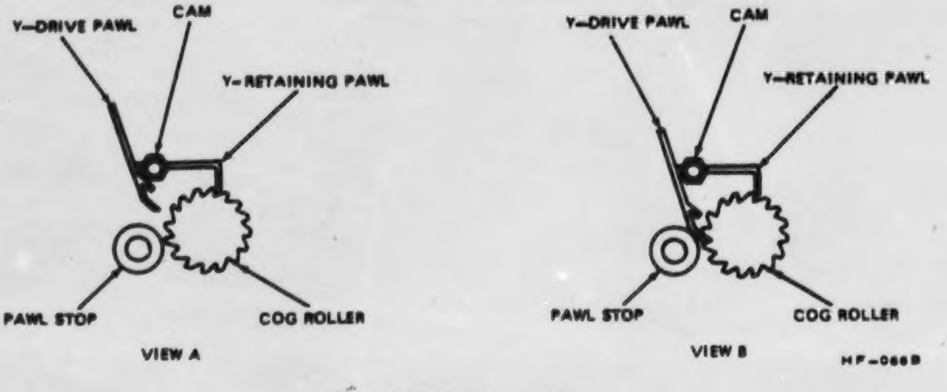


Figure 2-29. Y-drive mechanism.

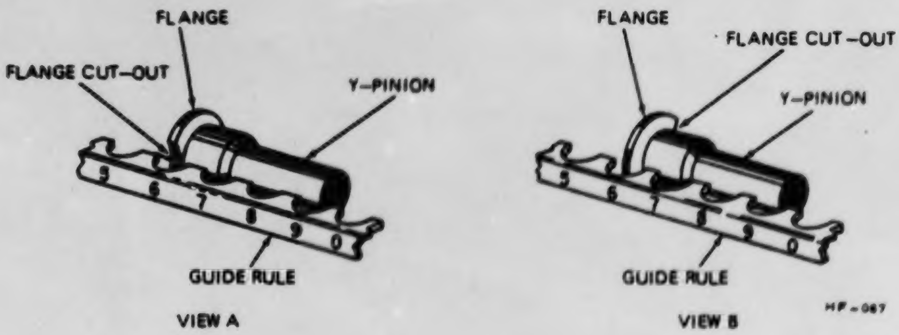


Figure 2-30. X-direction locking mechanism.

When the Y magnet operates, the drive pawl rocks forward to engage the ratchet teeth on the cog roller. As the Y armature continues in its travel, the cog roller is rotated so that it moves the Y carriage (fig. 2-20) one step in the Y direction. Y armature overtravel is prevented by the pawl stop. The position of the drive mechanism, with the Y magnet fully operated, is shown in figure 2-21,B, with cog roller rotation. The Y retaining pawl engages the next ratchet tooth on the cog roller to prevent the roller from returning to its home position. Back pressure on the cog roller is supplied by a coil spring located within the cog roller.

The method of arresting the Y motion of each step is shown in figure 2-21,B. As long as the Y magnet remains operated, the Y drive pawl is against the pawl stop and engages the ratchet gear of the cog roller. The lower angle of the Y drive pawl is such that the cog roller locks and is not free to rotate any further. When the Y magnet restores, the Y drive mechanism returns to the position shown in figure 2-21,A.

The Y interrupter springs (figs. 2-28 and 2-20) are mounted on the rear of the Y stepping mechanism. Each time the Y magnet operates, the Y armature is pulled down. This raises the bumper and relieves the pressure on the upper Y interrupted spring, allowing the spring contacts to open.

X and Y carriage assemblies. Figures 2-17 and 2-20 show the tip view of the X and Y carriage assemblies. The Y carriage assembly consists of the Y carriage and Y pinion. Gears on the Y pinion engage teeth on the Y carriage in such a manner that it must move in the X direction with the X carriage but is free to move independently in the Y direction. The X carriage is connected to the cog roller assembly so that cog roller translation results in an equal amount of X carriage translation. The Y pinion is also mechanically coupled to the cog roller assembly so that roller rotation results in an equal amount of Y pinion rotation.

A flange, in the Y pinion, is so constructed that further X stepping is impossible once the X carriage is advanced in the Y direction. With the Y pinion normal, a cutout in the flange allows the X carriage to move freely along the guide rule, figure 2-30,A.

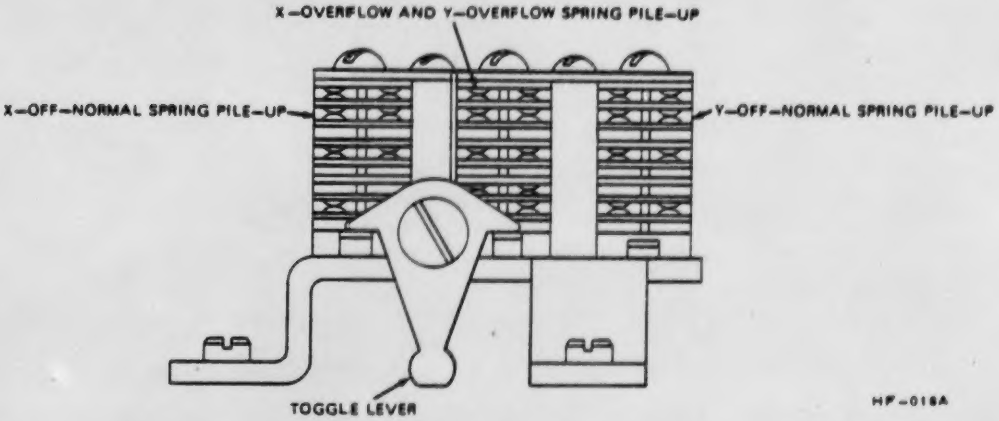

X–OVERFLOW AND Y–OVERFLOW SPRING PILE–UP
X–OFF–NORMAL SPRING PILE–UP
Y–OFF–NORMAL SPRING PILE–UP
TOGGLE LEVER
HF–018A

Figure 2-31. Spring pile-ups.

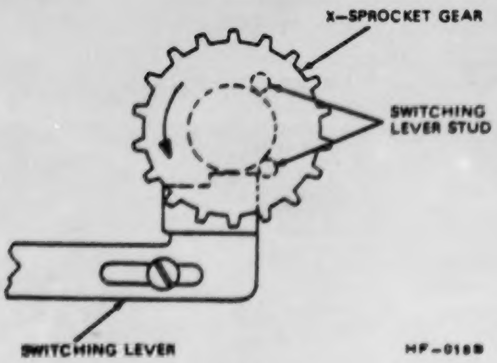


Figure 2-32. Switching lever control.

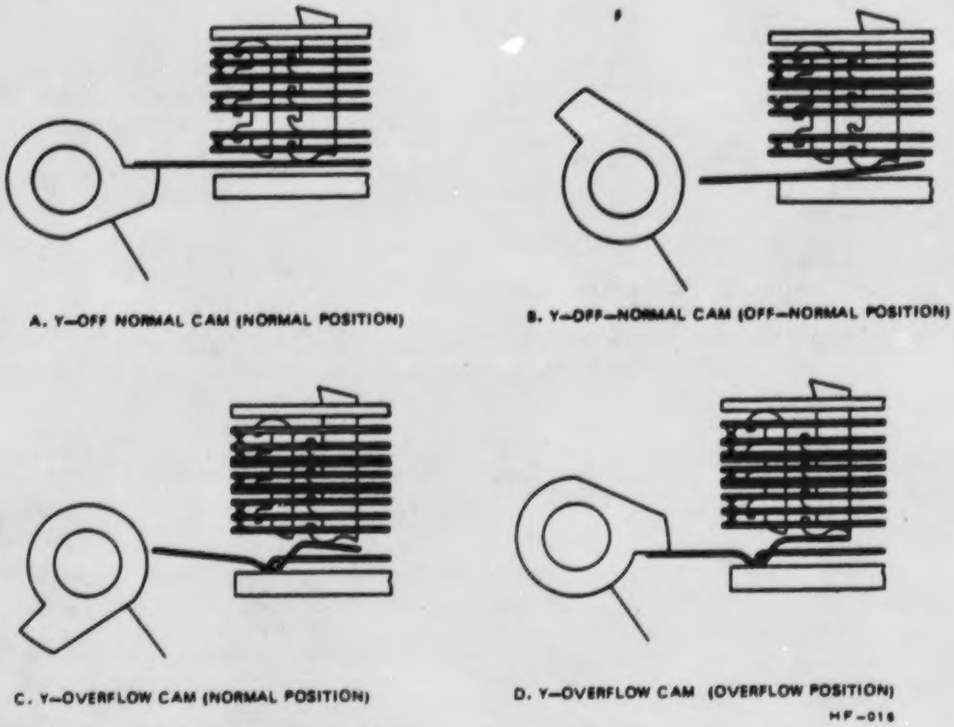
However, once the Y pinion is rotated, the cutout is repositioned so that the flange engages one of the cutouts in the guide rule, figure 2-30,B.

X and Y off-normal and overflow spring pileups. The X off-normal spring pileup and overflow spring pileup (X control) are controlled by the switching lever connected to the toggle lever as shown in figure 2-31. The switching lever is located on the baseplate directly below the cog roller assembly and is mechanically coupled to the X gear cluster, figure 2-32. Two studs mounted on the under side of the X sprocket gear control the movement of this lever. The normal position of this mechanism is shown in figure 2-32.

When the X sprocket gear is rotated in the direction shown in figure 2-32 by the arrow, resistance to motion is removed from the switching lever. The toggle lever in figure 2-32 is normally under tension from the X off-normal spring pileup. Thus, the switching lever is found to move and to allow that pileup to operate.

If the X sprocket gear is rotated so much as to send the X carriage into overflow (11 steps in the X direction), the overflow pileup is operated. The switching lever stud engages the switching lever on the 10th X step so that the 11th X step forces the switching lever to move. This operates the toggle lever which, in turn, operates the overflow pileup. Since there are but 10 cutouts in the guide rule of figure 2-30, the flange of the Y pinion becomes so positioned as to prevent any movement in the Y direction. The overflow spring pileup will remain operated as long as the X carriage is in overflow.

The Y off-normal spring pileup and overflow spring pileup (Y control) are controlled by two cams mounted on one end of the cog roller assembly. These cams rotate whenever the cog


A. Y—OFF NORMAL CAM (NORMAL POSITION)

B. Y—OFF—NORMAL CAM (OFF—NORMAL POSITION)

C. Y—OVERFLOW CAM (NORMAL POSITION)

D. Y—OVERFLOW CAM (OVERFLOW POSITION)

Figure 2-33. Spring combination operation by Y-off-normal and overflow cams.

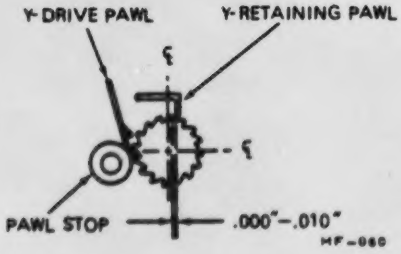


Figure 2-34. Centerline of cog roller.

roller is rotated. Figure 2-33 shows the operation of the Y off-normal and overflow cams.

Adjustments. Now it is time to take a look at some of the specifications for adjusting the XY Universal switch.

X stepping mechanism. When making adjustments to the X stepping mechanism, the first requirement is X gear cluster, lineup, and backlash. This is done by checking to see that the centerlines of the X gear cluster, its index hole, and engaging tooth are perpendicular to the axis of the cog roller. Now, that sounds like a mouthful, but it isn't. Look at figure 2-26 and draw an imaginary line straight down from the index hole, through the X-post nut, and along the edge of the X retaining pawl where it engages the X ratchet gear. If all three are on the line and the line is perpendicular to the cog roller, you have it made. If it isn't, there are a couple of things to do. First, loosen the X post nut just a little; second, disengage the X retaining pawl from the X gear ratchet and then shift the X gear cluster very carefully, until the index hole and the X post nut are on a line perpendicular to the cog roller. Then adjust the X retaining pawl until it is on the imaginary line and it drags slightly when disengaged from the X ratchet gear, using a fingernail.

Now for the backlash adjustment. Backlash in this case is the quick, sharp recoil between the sprocket gear teeth, figure 2-26, and the teeth of the cog roller. This is done first with the cog roller in the normal, at home position and then sliding the cog roller slightly to the right. This adjustment is gaged by eye, and there should be from .000 inch to .010 inch between the sprocket gear tooth and the mating cog roller tooth. If the requirement is met, check it with the switch in the X-5 and X-10 position. If it is not met, loosen the X post nut and reposition the X gear cluster and try again.

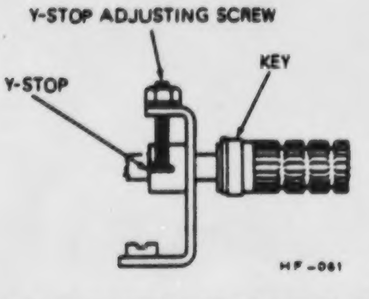


Figure 2-35. Y-stop assembly, left end of switch shaft.

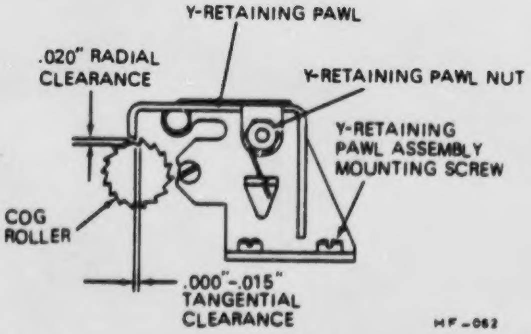


Figure 2-36. Y-retaining pawl assembly.

From here we go to one of the Y mechanism adjustment requirements.

Y stepping mechanism. The requirement for the Y retaining pawl and Y stop is the one we now consider.

Before we start, however, a word of advice. USE THE FIGURES IN THE TECHNICAL ORDER! You have heard it said that "A picture is worth a thousand words." This is particularly true when it concerns something of a technical nature. The technical orders we use contain words like annular, tangential, etc. They are words you don't use every day and may throw you somewhat; but, if you look at the figures that come with the instructions, they normally clear things up for you. Now on to the requirement.

The first requirement states that the Y retaining pawl assembly is to be so positioned that the inner face of the pawl is approximately .010 inch ahead of the centerline along the axis of the cog roller. Look at figure 2-34; the inner face of the Y retaining pawl is the side closest to the Y magnet assembly. There are two lines running down through just right of the centerline of the cog roller. This requirement does not deal with the pawl mating with cog roller teeth but with the inner face of the pawl extending .000 inch to .010 inch ahead of the centerline of the cog roller. This requirement is met by loosening the mounting screws of the Y retaining pawl assembly and sliding it into proper position, then carefully tightening the screws.

The next requirement states that the tangential clearance between the Y retaining pawl and its mating *tooth* on the cog roller must not exceed .015 inch at its most open position with the play of the cog roller key eliminated. We are dealing with two things here. Cog roller key play is found by turning

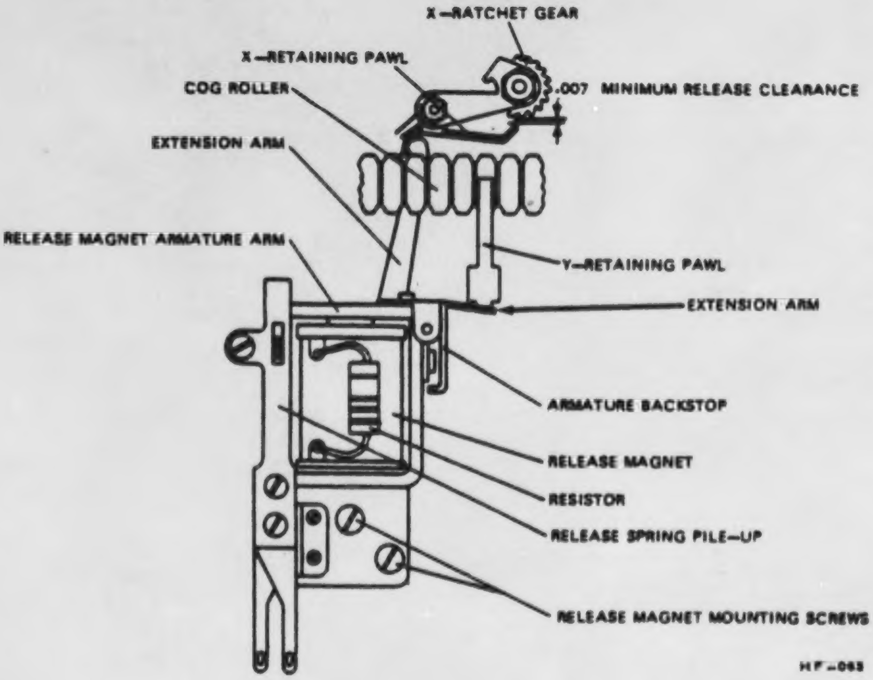


Figure 2-37. Release mechanism, top view.

the pinion gear from the top, slightly toward the back of the switch or counterclockwise (fig. 2-34). Check the movement by looking at the key (fig. 2-35), wipers, and the retaining pawl. This movement shows the tangential clearance, see figure 2-36, between the Y retaining pawl and the mating tooth of the cog roller. When turning the pinion gear, you turn it only until the shaft starts to move. The distance that the cog roller and pinion gear move from the start of the turn until the shaft starts to move is the play. If at this point the clearance exceeds .015 inch between the pawl and cog roller tooth, there is too much play.

The excess play is eliminated by adjusting the Y stop adjustment screw. The first step is to loosen the locking nut shown in figure 2-35. Once this is done, turn the Y stop adjustment screw counterclockwise. Check the tangential clearance and readjust until the clearance requirement is met; then carefully tighten the locking nut so that the adjustment is not disturbed.

Two down and one to go. With the Y carriage in the normal (home) position, the radial clearance between the Y retaining pawl and the root of the cog roller *tooth* should be a maximum of .020 inch. Take a look at figure 2-36; it clears up things like root of the cog roller tooth. What the requirement is, is a space with the switch and Y retaining pawl at normal of not more than .020 inch. It is gaged by eye and is easy to check. Push down on the top of the pawl; it should go down into the cog roller tooth. If the pawl moves down more than .020 inch before it hits the root of the cog roller tooth, you have an adjustment to make. Look at figure 2-37 at the extension arm of the release magnet armature assembly. It rests against the Y retaining pawl; by carefully bending the arm, your adjustment is made.

With your knowledge of switch components, switch functions, and the mechanics of various switch operations, along with technical data, switch adjustment should not be difficult.

Exercises (212):

Identify what adjustments need to be made and the tool(s) used to make each adjustment for the problems stated below.

1. The switch oversteps in the X direction.

2. The switch cannot step to Y-11. The problem is not in the Y magnet assembly.

3. The switch indicates it is stepped farther in the Y direction than it really is.

4. The X magnet, when energized, does not pull the X armature to it.

5. The switch takes one Y step during testing in the switch test set and goes no farther, the Y magnet does not deenergize.

213. State how selected switch adjustments affect other adjustments.

XY Switch Adjustment Relationships. The XY Universal switch adjustments relate to one another far more than in the Strowger two-motion stepping switch. It is easy to see, then, why a thorough knowledge of these relationships is important.

We do not attempt to cover all the adjustment relationships; but rather, make you look at the switch and use the information you already possess to see these relationships.

X stepping mechanism. When the X magnet operates, it causes the armature to pull up and the X interrupter contacts to open. The armature moves, causing the attached pawl to engage the X gear cluster and turn it. The X gear cluster moves the cog roller in the X direction as it turns; it also allows the switching lever to move. The switching lever, in moving toward the X gear cluster, operates the X-off-normal (XON) pileup. This goes on and on. Look at figure 2-17 and find the X retaining pawl. You remember that in technical school, the first thing you did when you were adjusting the XY switch was to adjust the X retaining pawl. It is a logical place to start; it is the home or normal position. Sometimes it is necessary to move the retaining pawl assembly; this often means loosening the ejector strap that also connects to the X gear cluster. Now, once that adjustment is made, what adjustments have you affected? Would you believe the adjustment dealing with the place that the X armature pawl strikes the X ratchet teeth?

Let us look at Y stepping mechanism.

Y stepping mechanism. The Y retaining pawl keeps the shaft from returning to Y normal during Y stepping. Its adjustment is not difficult, but think about the other adjustments that it affects. See figure 2-20. If affects the position of the wipers. If the adjustment is changed, the wipers either step past or step short of a bank contact. It also throws the digit drum adjustment off as well as the tangential clearance adjustment.

Release mechanism. Figure 2-22 pictures the release components. What could it possibly affect? It either releases the switch or it doesn't. When you loosen the mounting screws and move the release magnet assembly just a little, what have you affected? Think about it before reading further. You have changed the radial clearance between the Y retaining pawl and the cog roller. You may have done something even more important; the switch may try to release X first, instead of Y. That is hard on wipers.

We could go on with this, but the truth is that you already have the information, and with the figures provided in this chapter or an XY switch itself, you can identify the other relationships.

Exercises (213):

State what switch adjustments are affected by the change in the adjustments listed below. Use figures 2-15 through 2-37 as needed.

1. The Y retaining pawl assembly is moved forward (toward the cog roller).

2. Only the X retaining is moved very slightly to the left (toward the left bearing).

3. The release magnet is moved slightly counterclockwise.

4. The step screw is turned one-half turn counterclockwise.

5. The front screw (nearest the wire banks) of the cog roller support is tightened slightly.

CHAPTER 3

Telephone Systems Fundamentals

WHEN IT COMES to telephone systems, sound, transmitters, and receivers are about as fundamental as you can get. Isn't that what a telephone system is all about? Just about; getting sound from one place to another means that you need a way to get the sound where you want it.

That is what this chapter covers. We look first at sound; what it is and how it travels. Then we tie it together with a transmitter and receiver, which enables sound to travel further than it can in the air. We discuss the relationship of the original sound wave, what happens to it after it strikes the transmitter and after it leaves the receiver.

We will also look at some of the telephone systems that make it possible for you to talk to someone who is out of earshot or whom you can't see.

3-1. Sound, Transmitters, and Receivers

Any telephone system begins and ends with sound. So, we will concern ourselves with the origin and characteristics of sound waves as an introduction to the elements and operational principles of a basic telephone system.

214. Given pertinent questions concerning the transmission of sound, supply brief answers.

Sound. Sound is the sensation caused in the nervous system by vibration of the delicate membranes of the ear. An analysis of sound as a sensation is not necessary, but we will mention that the causes of sound by physical vibrations can be analyzed and measured with accuracy. Sound results from the rapid vibration of a rigid or semirigid body; for example, a hacksaw blade (see fig. 3-1). If you hold a pencil lightly against the vibrating body, the physical motion often may be felt by the hand. Without the pencil as a medium for the transfer of energy, the vibrations cannot be felt, even at a small distance from the source. Although you could not feel the vibrations with the hand, they are heard by the ear as sound. The physical medium between the source of vibrations and the ear is the air, which is set in motion by the vibrating body and carried to the delicate and sensitive membranes of the ear.

Other mediums, either solid or liquid, can transmit sound. For instance, a boy lays his ear against a railroad track to detect an oncoming train which is too far away for its sound to reach him through air. You know, too, that the American Indian is reputed to have been able to detect far away footsteps by pressing his ear to the ground. In both cases, a denser medium carried the sound farther than the sound could travel in air.

Sound waves. The motion of the air molecules, set up by a body vibrating in air, produces sound waves which travel outward in all directions from the vibrating source. The manner in which sound waves are produced can be understood by considering a rapidly vibrating strip of metal, such as a hacksaw blade.

The hacksaw blade in figure 3-2,A, is shown at rest and the air particles are evenly spaced on both sides of it. As it moves to the right in figure 3-2,B, two events of opposite nature occur. One, the blade momentarily increases the pressure in the group of air particles adjacent on its right, causing a local *condensation* or bunching-up of the particles on that side. Two, the blade momentarily decreases the pressure in the group of air particles adjacent on its left, causing a local *rarefaction*, or dispersion of the particles on that side.

Condensation and rarefaction occur at the same time and are caused by the single motion of the blade to the right.

If free to vibrate by itself, the blade starts to move to its vertical position of rest as in figure 3-2,C; but motion has been imparted to the particles on each side, and their subsequent behavior is affected. The bunched-up group on the right has been given a velocity outward, and pushes against the layer of particles still farther to the right. Great numbers of minute collisions occur and the striking particles give their neighbors their own motion and bunched-up arrangement. This accounts for the new position of the regions of condensation and rarefaction. This outward

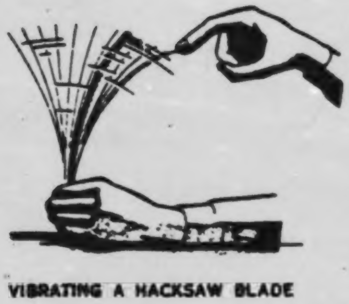


Figure 3-1. Vibrating a hacksaw blade.

progress continues; the wave of sound energy moving rapidly outward, but the individual air particles that transmit the motion remain behind.

As the blade returns left toward the vertical and the condensation travels outward to the right, an increasing gap occurs between them, as shown in C of figure 3-2. This region becomes one of lessening pressure because the nearby air, particles tend to rush in and fill the gap to normal density. By the time the blade reaches the vertical, the pressure immediately to its right has decreased to about normal, and normal pressure has been restored just to its left.

The blade at this point has a good deal of velocity and continues to the left as in D of figure 3-2. It now has caused a condensation on its left and a rarefaction on its right. The initial condensation on the right, meanwhile, has progressed still farther from the blade, and the initial rarefaction still farther to the left.

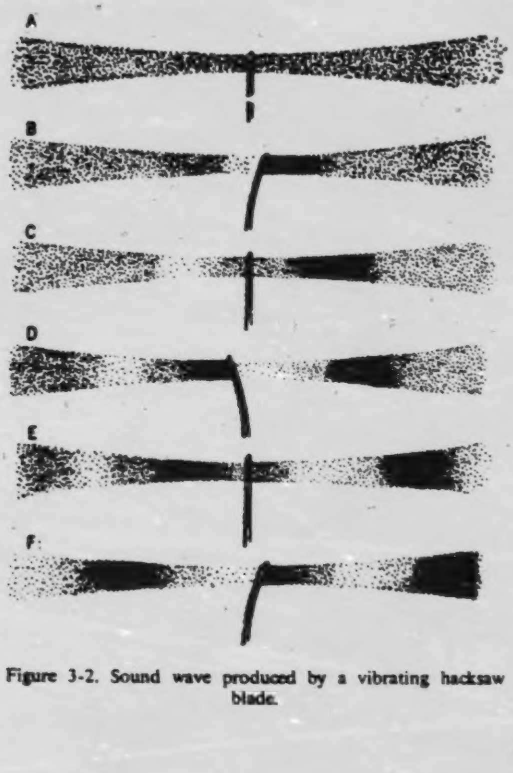


Figure 3-2. Sound wave produced by a vibrating hacksaw blade.

In this way, at each advance of the blade to either side, a crest of condensation is sent traveling outward; and at each retreat of the blade a trough of rarefaction is established. The energy of each wave, crest to crest, was given to it by transfer of the energy of motion of the blade. This energy, now called a sound wave, continues outward. The air particles which transmit the energy do not go along with it; each collides with its outside neighbors, imparts its energy, and returns to a point close to its original position. Thus, with the blade again vertical, normal pressure is restored on both sides of the blade as in E of figure 3-2. By this time, both condensation and rarefactions have moved farther out from the source and they are followed as in F of figure 3-2, by a new wave which has been forming. The process continues and a train of waves is sent out as long as the vibration continues.

Representation of sound waves. Sound waves may be represented on a graph by plotting the relative compression of the air particles of successive groups against their distance from the source or against time.

In figure 3-3, a portion of figure 3-2 is redrawn showing the particles comprising several sound waves. The alternate regions of condensation and rarefaction are moving toward the right, as explained before. Below this representation is a

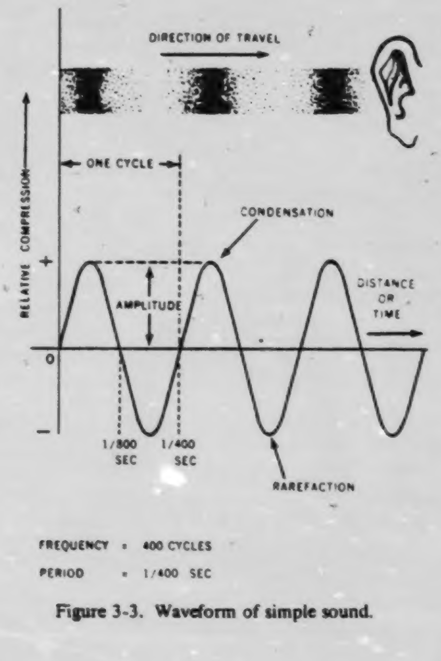


Figure 3-3. Waveform of simple sound.

graph on which the vertical distances correspond to the relative compression of the air particles along the path of the wave. Note that the highest points of the curve (positive peaks) lie beneath places of maximum condensation, the lowest points of the curve (negative peaks) lie beneath places of maximum rarefaction and points on the horizontal axis lie beneath places of medium density.

Since the wave is traveling to the right, the ear of the listener experiences variations of pressure identical with those existing along the path of the wave; first, the rarefaction farthest to the right, then the adjacent condensation to the left, etc. This is because the entire train of waves is moving toward the ear from the left. For this reason, the graph of pressure against time at any point is identical with the graph of pressure against distance at any instant, and horizontal distances may represent intervals of time.

This particular graph represents the sound waves set up by an object vibrating 400 times each second. The time required for each complete vibration is, therefore, 1/400 second.

The number of complete vibrations of the object that occur in 1 second is the same as the number of cycles of the wave that occur in 1 second. This number is called the frequency of the wave. A cycle is a complete set of pressure values, from one positive peak to the next, anywhere along the path of the wave. The words "cycles per second" usually are expressed as hertz. The time required for one cycle to occur is called the period of the wave. It usually is measured in seconds or milliseconds. The period is the reciprocal of the frequency. For example, the frequency of the waveform illustrated in figure 3-3 is 400 hertz, but the period is 1/400 second or 2.5 milliseconds.

The maximum value of the wave measured from the zero axis is called the amplitude of the wave. The sound represented in figure 3-3 is a pure tone such as made by a tuning fork. Since its graph is a sine wave, the terms which apply to electrical sine waves also apply to it.

Complex sounds. Most sound sources in telephony do not produce sounds of the simple form represented by the sine wave of figure 3-3. Those usually encountered are complex sounds consisting of two or more simple sounds, each having its own frequency and amplitude. The variations of the voice are of considerable importance in telephony, for any part of the telephone system which suppresses or distorts them makes the received sound less intelligible.

Frequency and amplitude of sound are the two most important qualities of sound from the standpoint of voice communication. Speech frequency is determined mostly by the speed of vibration of the speaker's vocal cords. Frequency determines the pitch of a sound. The sound of a siren starts at a low frequency, goes to a high frequency, and ends at a low frequency. The human ear can detect sounds from about 20 hertz to about 20,000 hertz. Most speech requires only the frequencies between 200 and 3,000 hertz. Amplitude of sound is closely related to loudness. It is determined largely by the power used in speaking.

Why is this business of frequency and amplitude important to a central office mechanic? The telephone circuits that you maintain and repair must pass enough sound frequencies to make speech understandable. The sound amplitude at the receiver must be great enough to be heard. Poor connections reduce amplitude. Wrong sizes of certain components or faulty components can reduce frequencies and amplitudes to such an extent that speech is not understandable. The part of the telephone system that sets up and controls the frequencies and amplitude in the circuits during a telephone conversation is the telephone.

By means of the telephone, conversations may be held over great distances. To accomplish this, the sound waves of speech must be converted into a form of energy that can be transmitted efficiently over wires. The conversion produces electrical waves (current) in the transmitter of the speaker's telephone set. The electrical waves which are created correspond to sound waves both in waveform and frequency. The electrical waves are transmitted over the transmission line and enter the

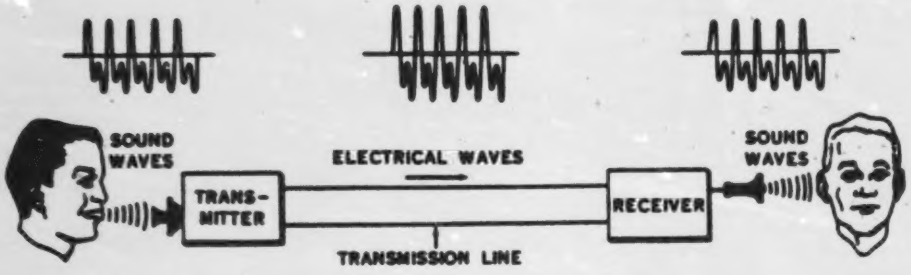


Figure 3-4. Transmission of sound by telephone.

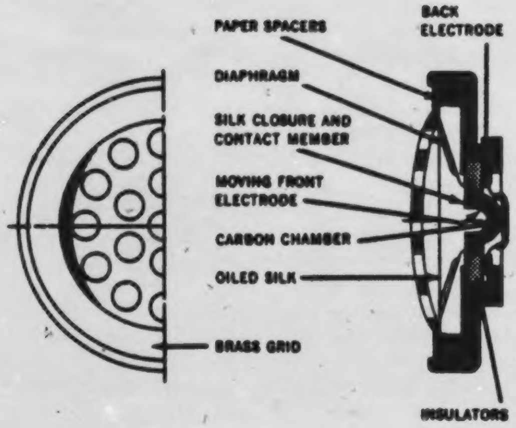


Figure 3-5. Telephone transmitter.

receiver of the listener's telephone set. The receiver converts the electrical waves back into sound waves which again correspond in waveform and frequency to the original sound waves. The listener from his receiver thus hears words corresponding to those spoken into the distant transmitter. This is illustrated in figure 3-4.

The fundamental principle of the telephone can be summarized by the explanation that electrical waves, traveling over wires, are substituted for sound waves traveling in air, over the major portion of the distance separating the speaker and listener.[4] Various types of telephone systems are in use, but this principle is common to them all.

Operation of the telephone presents some rather complex problems which do not occur in transmission of sound through air. These problems include distortion of the sound, noise generated mechanically and electrically in the telephone system, noise from external sources, the cutting off of some of the low- and high-frequency components of the sound, and the reduction in volume which occurs in long-distance transmission. All of these problems tend to reduce the clearness of the words, the naturalness of the tone, and quality of the sound. These problems arise from the wires, from the component parts of the equipment and from the associated circuits required for the generation of power. The engineer must consider all of these problems in designing telephone equipment, and both the operator and the maintenance man must be familiar with them to secure the best possible operation of the equipment. Particularly, distortion of sound and distraction from external sources must be kept at a minimum, since the personal contact so important in face-to-face conversation, is lacking.

The Telephone Transmitter. The two basic parts of the transmitter are a metal-disc (diaphragm) and a carbon pocket. The diaphragm is a thin metal disc which vibrates when sound waves strike it. Figure 3-5 is a picture of a transmitter and figure 3-6 shows a simplified drawing of a receiver network. A button is attached to the center of the diaphragm and extends into the carbon chamber. The carbon chamber is loosely filled with grains of carbon. When the diaphragm vibrates, the button packs the carbon granules as it moves inward and loosens the granules as it moves outward. The carbon-filled chamber acts like a valve for electrical current. More current flows when the granules are packed, and less current flows when the granules are loose. Thus, the current flow through a

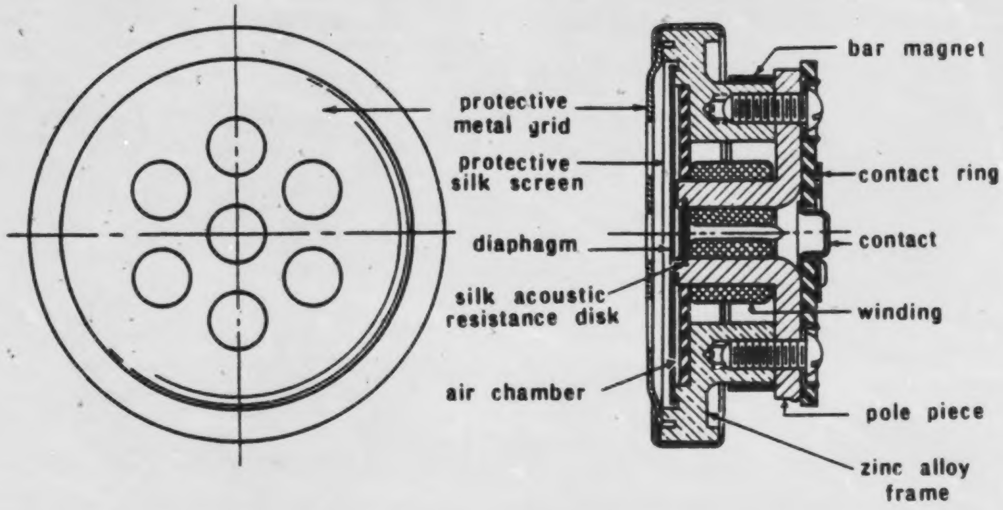


Figure 3-6. Telephone receiver.

transmitter varies with the frequency and amplitude of sound waves.

The Telephone Receiver. A telephone receiver is shown in figure 3-6. Its three basic parts are a thin metal diaphragm, a permanent magnet (bar magnet), and a coil of wire (winding). The coil is arranged so that its magnetism aids or opposes the permanent magnet. The current which flows through the receiver coil results from the transmitter current which varies as the sound waves vary. The receiver diaphragm is placed near the magnet so that it is attracted more or less by the varying magnetic force. The receiver diaphragm thus vibrates at the same rate as the electrical waves. As the diaphragm vibrates, it sets air particles into motion; the electrical waves are changed into sound waves.

Exercises (214):

Complete the following about sound, transmitters, and receivers.

1. What is the definition of sound?

2. What does sound result from?

3. Name three types of mediums with respect to sound.

4. What is a medium, with respect to sound; how does it work?

5. In what form does sound travel through air?

6. What are condensation and rarefaction?

7. What does the representation of pure tone sound waves resemble on a graph?

8. What three values of a sound wave can be determined from a graph of the sound wave?

9. What are the two major parts of a telephone transmitter?

10. What is the basic function of a telephone transmitter?

11. What action in the transmitter increases the current in the transmission line?

12. What is the relationship between the frequency and shape of the sound wave applied to the transmitter and the resulting electrical signal on the transmission line? Why?

13. What are the three basic parts of a telephone receiver?

14. What does each major part of a receiver do in converting the current wave to sound?

15. What is the relationship between the frequency and waveshape of the electrical signal of the transmission line and the resulting sound wave at the receiver? Why?

3-2. Telephone Systems

To connect our telephone with other telephones of our choice, central switching systems are used; that is, all of the telephones in a given area are connected to a switchboard or central office by telephone lines and cables. The central office, or switchboard, does the necessary switching so that any two lines in the area may be interconnected for two-way conversation. Also, connections are provided by the central offices for connecting telephones in one area with the telephone systems of other areas. Thus local or long-distance connections may be made.

The systems used at the present fall into two classifications: nondial (manual) and dial (automatic) telephone systems. In the nondial system, all telephone connections are set up manually at the central office. That is, the operator completes the connection at the spoken request of the calling party. In the dial system, the connections are set up automatically by electromechanically operated switching mechanisms under the remote control of the dial used by the calling party.

Although most of the telephone systems used today are of the dial (automatic) type, there are some manual circuits and systems still in use. It has been the normal trend, however, as telephone systems were developed, to replace the older components with units of more modern design. Thus the development and improvement of telephone systems is a continuing process.

215. Given statements about a manual or automatic system's function, state how the same function is accomplished by the other system and identify those functions that are the same in both systems.

The history of telephone systems dates back to about 1876, when Alexander Graham Bell invented the first practical telephone. Once its practicability was established, a search began for ways of improving the quality and extending the scope of this instrument. The search has been continuing ever since; each year new improvements are perfected. Naturally, as telephone systems became larger and more involved, inventors concentrated more and more on the development of automatic installations in which electrically operated machines replaced manual switchboard operators.

Many people living today were introduced to telephone service by equipment which required many more actions by the subscriber than does today's equipment. These early manual-type switching components provided effective service to a limited number of subscribers at a price which was then acceptable. But the demands for increased service taxed excessively this equipment and the men that cared for it. In fact, the type of equipment then in use was unable to give efficient service to such a massive group of subscribers. Several features that made this equipment unsatisfactory were:

- Long-distance calls took too much time to originate, and after you had your party, it was often impossible to hear what was said.
- All the connections were made by operators; and these people required regular salaries, which increased the expense of service.
- A completed call had to be verified by recalling the operator. This action was often neglected, causing extra work for the operator.
- The components of the equipment were often large and cumbersome, which made the equipment unnecessarily large. Also, some components were short-lived, requiring regular replacement.

The progress of automatic switching, through the efforts of men who were curious and unsatisfied, has permitted extensive improvements in telephone service. Today you can dial numbers and get the desired connection without the assistance of an operator. The party whom you wish to speak with may be anywhere in the United States or in certain other areas of the world. Future developments are unlimited. Also, there is seldom a need for you to talk more forcefully than you normally would in order for your listener to understand you. When you terminate a call, you return the handset to the telephone, and automatically the equipment returns to the idle condition to await another call. In addition, the cost is very reasonable when compared to the expense of telephone operations and the quality of that service in those earlier years.

There have been many devices originated and placed in use by the competing industries. For the most part, these many devices have been the cumulative developments of several individuals. For instance, the first automatic switching machine was patented in 1879, but proved to be impractical. Its basic idea was further developed and then patented in 1891. This switching device is presently referred to as a step-by-step switch, because it operates upward one step at a time and then rotates around in a similar fashion to make a desired connection. It now appears that many of these devices are transitional units, because so many developments are under way that the present systems may be obsolete within your lifetime.

System Development. What occurred in a system that permitted a subscriber of these early years to converse with the person at the second telephone?

With the simple telephone system, the operator completed the telephone connection between the two subscribers by a cord circuit. The calling subscriber signaled the operator, who inserted a cord circuit's answer plug into the proper jack. After receiving the number or name of the subscriber to be called, the operator inserted the plug at the other end of this cord circuit into the jack associated with the line of the called subscriber. The operator then provided ringing current to the line, which rang a bell in the called telephone set. During the conversational period, the operator continued making connections for other subscribers of the exchange. Termination of the previous call by the originating subscriber required him to rering the operator in order to get the switchboard cord restored to the plugshelf. The failure of many subscribers to notify the operator caused a switchboard to be tied up or busied.

To overcome this discrepancy, a method was developed to indicate the terminaton of a call automatically. Other improvements accompanied the change, too. Every subscriber, as a normal action, had to remove the telephone handset to make a call and then restore it on the telephone at

TABLE 3-1

COMPARISON OF METHOD AND PROCEDURE FOR INTERCONNECTION BETWEEN LINES—MANUAL AND DIAL CENTRAL OFFICES

	OPERATION	MANUAL	AUTOMATIC
1	Subscriber initiating call picks up his handset (hookswitch closes).	Line relay in C.O. operates.	Line relay in C.O. operates.
2	Line relay operates.	Lights lamp on swbd. (associated with calling subs. Line ckt. - and jack) to signal operator.	Marks position (electrically) of calling subs. line and signals automatic linefinding equipment.
3	Signal	Operator picks up answer plug and connects to calling line jack.	Linefinder hunts automatically for calling line.
4	Instructions from Central Office	Operator throws talk-ring key to talk position and says "Number please".	Linefinder connects calling line thru to next switch. Next switch returns dial tone back to calling subs.
5	Instructions from calling party	Subscriber tells operator number of desired subscriber's line.	Subscriber dials number of station desired.
6	Interconnection of the subscribers	Operator picks up call plug of cord circuit and connects to called line jack.	Dial pulses control connector. Connector moves to called line appearance.
7	Signaling desired station (ringing called party).	Operator throws talk-ring key intermittantly to ring position.	Connector automatically connects interrupted ringing to called station line.
8	Called subscriber picks up handset.	Signals operator. Operator stops ringing.	Connector switch automatically cuts off ringing current.
9	Power for subscriber's transmitters.	Furnished from C.O. battery thru Swbd. cord circuit (if common battery system).	Furnished from C.O. battery thru connector switch circuits.
10	Talking channel established.	By operator with use of cord circuit at C.O. swbd.	Automatically with switching equipment at C.O.
11	Disconnection. Subscribers replace handsets on telephones.	Subscriber's hookswitch controls disconnect (supervisory) signal in cord circuit being used.	Subscriber's hookswitch opens. Switching equipment releases.

the completion of the call. These operations initiated actions that notified the operator of a need for service. The telephone was constructed in such a manner that a lifted handset caused a lamp to light at the switchboard, and replacement of the handset on completion of the conversation caused other lamps to light. The switchboard supervision of calls was greatly improved by this development.

Now what occurs in the telephone system that lets you converse with your girl friend, boss, mother, or father? Stepping-type switches provide the connections in the Strowger and XY systems.

The description of the connecting process is going to take much longer than the call that you made. When finished, we hope that you understand it as well as you did your most recent telephone conversation.

System Similarities. Each telephone system must have a unit of equipment which permits attachment to the wires from the telephone. The same unit also terminates cables from the central office equipment. The nomenclature for this unit is the main distributing frame (MDF). An additional frame that permits termination is the intermediate distributing frame (IDF). In larger exchanges, a single frame is used for both these frames. It is the combined distributing frame (CDF).

The wires that connect the telephone and the MDF are referred to as *lines*. One wire of a line is called the *tip* side and the other is called the *ring* side. Between the MDF and the equipment are the tip (T), ring (R), and *control* wires. The manufacturers use varying abbreviations for these leads, though. In common usage is a + for the T lead; a − for the R lead; and a/an S, HS, or C for the control lead.

Most telephone subscribers must be able to originate calls as well as receive calls. The MDF, therefore, must have strapping or jumpering which permits this. The terminal pins that serve a subscriber's incoming lines are jumpered to the terminal pins that connect with the central office outgoing wires.

Multiple is a term that the telephone people use for parallel. Equipment that is connected together in order to permit a choice in accessibility must be multiplied. Manual switchboards are multiplied when the number of subscribers is excessive for one operator. Connecting a second manual switchboard in parallel with the occupied switchboard permits a second operator to give assistance in servicing the calls. The largest percentage of multiplying in automatic switching equipment is done at the distributing terminal assembly.

Different automatic systems resemble each other in their equipment functions. Linefinding, selecting, and connecting equipment is found in the majority of exchanges. Other functions necessary for completing each call may be the same but are often assigned a different name. Examples of this are the distributing, allotting, or guard functions.

The power requirements for these exchanges are pretty well standardized. The equipment with each office, therefore, meets the same requirements, but with a variation in methods. Ringing may be accomplished with a mechanical ringing generator, with an interrupter, or with an electronic ringing generator. Large batteries are used in most of the central offices for filtering and for temporarily providing all the direct current in an emergency.

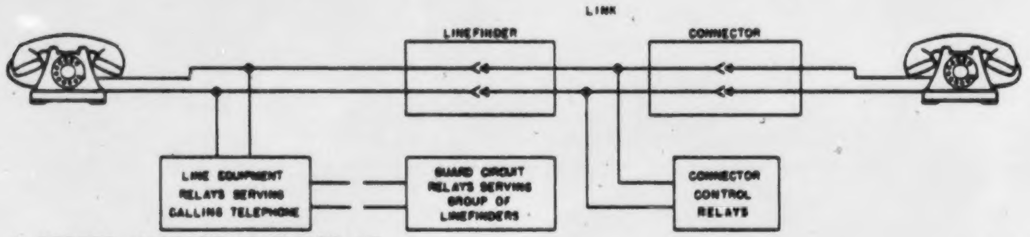
Since you are probably familiar with manual equipment, we will relate this discussion of automatic switching to manual equipment as closely as possible.

The equipment required to connect two telephones together automatically is known as a *link*. The simplest link is made up of a linefinder and a connector. The telephone central office which contains only these 2 elements serves fewer than 100 telephones. The directory number assigned to a telephone of this small exchange (switching center or central office) has two digits. This link in the system performs the same switching operations as does the switchboard operator in a manual system. The automatic connection of the linefinder with the calling telephone is the equivalent of manually inserting the answer plug into the switchboard line jack. The connector action completes the circuit to the called telephone, thus corresponding to the manual insertion of the call plug into the switchboard line jack of the called telephone. Ringing the called party is automatic with dial equipment.

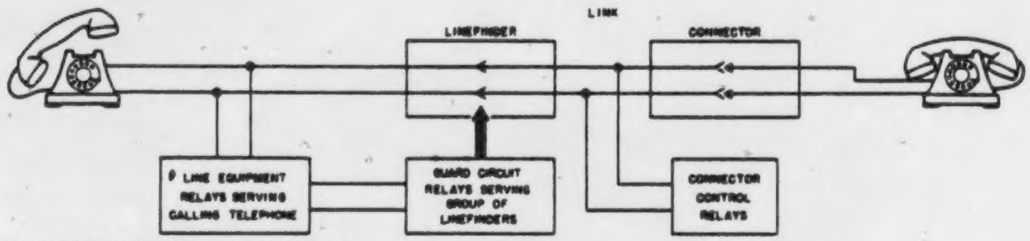
In a telephone exchange that serves more than 100 but less than 1,000 lines, a link consists of a linefinder, a selector, and a connector. In order that a connection may be completed through this link, a three-digit directory number is assigned to each telephone. A larger exchange, which uses a linefinder, a first selector, a second selector, and a connector has a four-digit assignment. This latter link limits the exchange to serving 10,000 lines.

Table 3-1 is a comparison between a manual system and an automatic system of the operations from the time that the calling party picks up his handset until the time that he hangs it back up. Should the called line be busy when he tries to use the dial system, the connection will not be completed; instead, the switch will operate in such a way that a busy signal (busy tone) will be connected to the calling line. This signal corresponds to the operator's "the line is busy" in the manual system. As you might suspect, a number of types of dial systems have been developed. Each system has its own advantages and disadvantages, and these, properly evaluated, determine the type most suited to a particular requirement. All dial systems are compatible; and it is difficult to identify one system as the best. In the older step-type system, 10 calls could be in progress simultaneously in a 100-line group; whereas in the more modern systems, the trunking percentage ranges up to 15 percent.

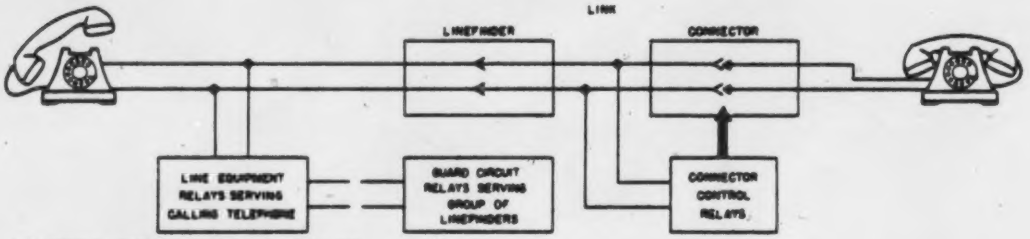
Though cost and economy have no direct bearing on quality of service, they must also be considered when selecting a system. For example, in large installations, retaining the same number of operators at the switchboard during slack times as during busy periods is uneconomical. If an emergency suddenly increases the traffic load during a normally slack period, the exchange becomes a bottleneck until additional operators can be brought to the switchboard. Therefore, a big advantage of an automatic central office is that maximum connecting facilities are available at all hours.


LINK
LINEFINDER
CONNECTOR
LINE EQUIPMENT RELAYS SERVING CALLING TELEPHONE
GUARD CIRCUIT RELAYS SERVING GROUP OF LINEFINDERS
CONNECTOR CONTROL RELAYS

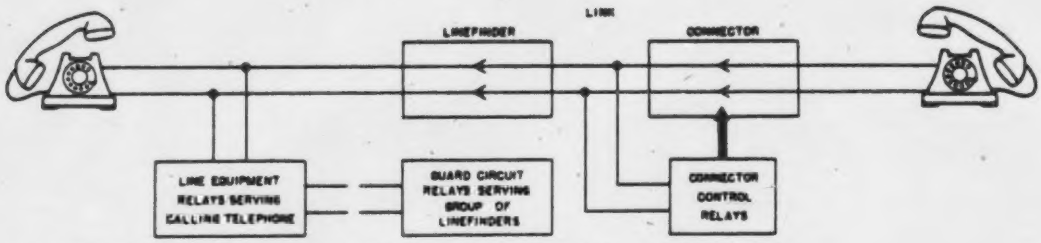
A BEFORE HANDSET IS PICKED UP


LINK
LINEFINDER
CONNECTOR
LINE EQUIPMENT RELAYS SERVING CALLING TELEPHONE
GUARD CIRCUIT RELAYS SERVING GROUP OF LINEFINDERS
CONNECTOR CONTROL RELAYS

B AFTER HANDSET IS PICKED UP


LINK
LINEFINDER
CONNECTOR
LINE EQUIPMENT RELAYS SERVING CALLING TELEPHONE
GUARD CIRCUIT RELAYS SERVING GROUP OF LINEFINDERS
CONNECTOR CONTROL RELAYS

C AFTER FIRST DIGIT IS DIALED


LINK
LINEFINDER
CONNECTOR
LINE EQUIPMENT RELAYS SERVING CALLING TELEPHONE
GUARD CIRCUIT RELAYS SERVING GROUP OF LINEFINDERS
CONNECTOR CONTROL RELAYS

D AFTER SECOND DIGIT IS DIALED AND CONNECTION IS COMPLETED

Figure 3-7. Block diagram of the connections which provide a telephone link.

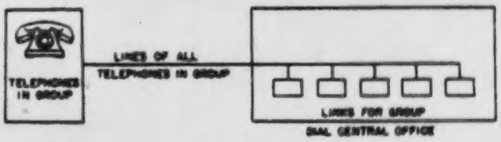


Figure 3-8. Telephone links connected in parallel.

The various automatic systems provide similar service features; they differ only in the manner by which interconnection between telephones is made. The two metallic wires that connect each telephone to the central office may be strung with wires on crossarms of poles or they may be part of the pairs in aerial or underground cables. Each telephone line is connected to line equipment relays in the central office through the MDF. Figure 3-7,A, illustrates this connection in block form. The MDF is not shown, but you can see that the line connection to the central office equipment is paralleled. One point within the office connects to both the line equipment relays and the linefinder.

Remember: The telephone is actually some distance from the office, but the equipment within the blocks is in the central office.

Figure 3-7,B, shows that lifting the telephone handset operates guard circuit relays to seize an available linefinder. At this time, also, the line equipment relays make the line unavailable (busy) to other calls while this telephone is being used. The operated linefinder extends the call by causing the connector control relays to seize an available connector. Dialing a number causes relays to operate and close or open gaps between contacts which, in turn, result in establishing proper electrical connections. Figure 3-7,C, pictures this effect. Dialing the second digit into our small exchange completes the connection between the calling and called telephone. Figure 3-7,D, indicates this action.

It was previously stated that the MDF strapping permits each telephone subscriber to originate calls as well as to receive them. To insure that this action is possible, all links are wired in parallel, as you can see in figure 3-8. This link is further broken down in figure 3-9 to show that the connector terminals and linefinder terminals multiple and then connect with the lines from the telephones in the group. The number of links wired in parallel for a group determines the number of simultaneous calls that can be made. One link is used for each talking connection. The 200-point telephone equipment parallels 20 links for each group of 200 lines. You should realize, then, that this system enables 20 calls to be made simultaneously. Linefinders and connectors are often referred to as equipped with "full-multiple," which means that every line connects with every linefinder and connector.

Functions of Switching Equipment. The automatic switching equipment in a dial central office performs the following functions: It connects and disconnects calling and called parties through intraoffice and interoffice trunks. To prevent interference with calls in progress, it tests all called lines to see if they are busy. If the called line is busy, the automatic switching equipment transmits a busy tone signal to the calling telephone. If the called line is idle, the automatic equipment rings the bells of the called telephone. The switching equipment also provides automatic trunk-hunting to PBX (private branch exchange) lines.

The switching equipment in a dial central office operates directly from the dial pulses transmitted by the dial of the telephone. These dial pulses are interruptions of current caused by the alternate opening and closing of the impulse springs in the dial mechanism. Each set, or series, of dial pulses corresponding to each digit dialed by the telephone user extends a connection one step at a time through the switching equipment to the called telephone.

Selecting the Called Telephone. From the information given previously, you can see that expansion of the basic switching system to serve more than 100 but less than 1,000 lines requires the addition of a first selector and a third digit in the directory number. This selector is directly connected to the linefinder's outgoing lines; thus the connector follows it in the link. Figure 3-10 shows 4 groups of 100 telephones connected to the associated linefinders and connectors. Between these two members of the link are the selectors. This figure indicates that only the selector of the 200 group is connected to all the connectors; but actually, the selectors of all the groups have access to all connectors. Thus, in this system, the first digit dialed selects a connector in a particular HUNDREDS group. You can see that trunks are indicated but they are not shown connected. In this illustrated 1,000-line exchange, there could be a maximum of 10 links for each 100 lines. As a result, then, there could be 10 calls made simultaneously in each 100-line group or 100 simultaneous calls are possible with the 1,000 lines.

Further expansion of the central office to 10,000-line service requires the use of a second

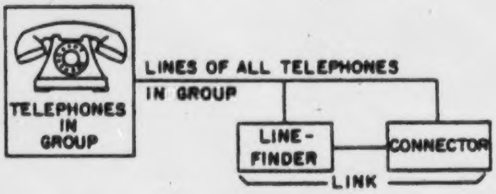


Figure 3-9. Block diagram showing parallel-connected line-finder and connected.

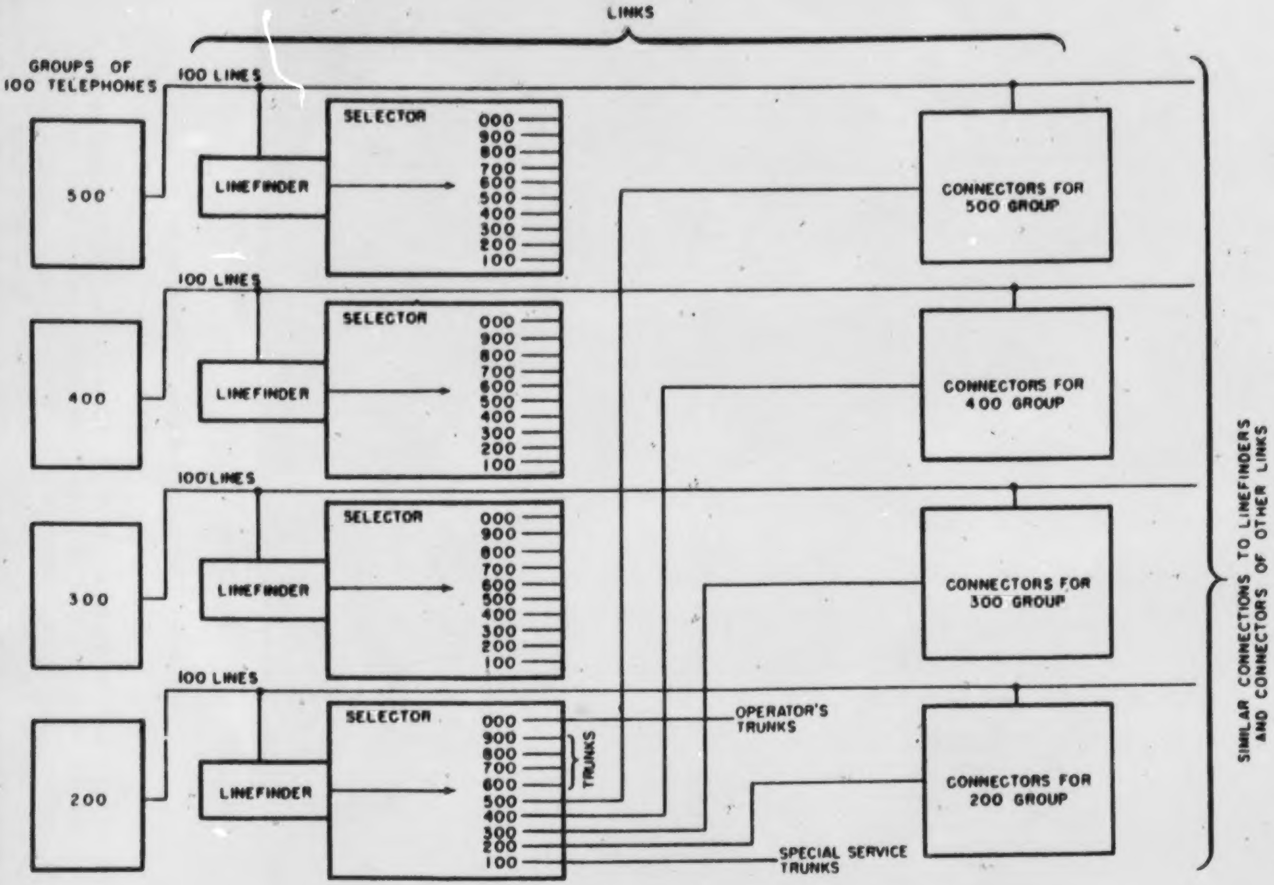


Figure 3-10. Theoretical 1,000-line system.

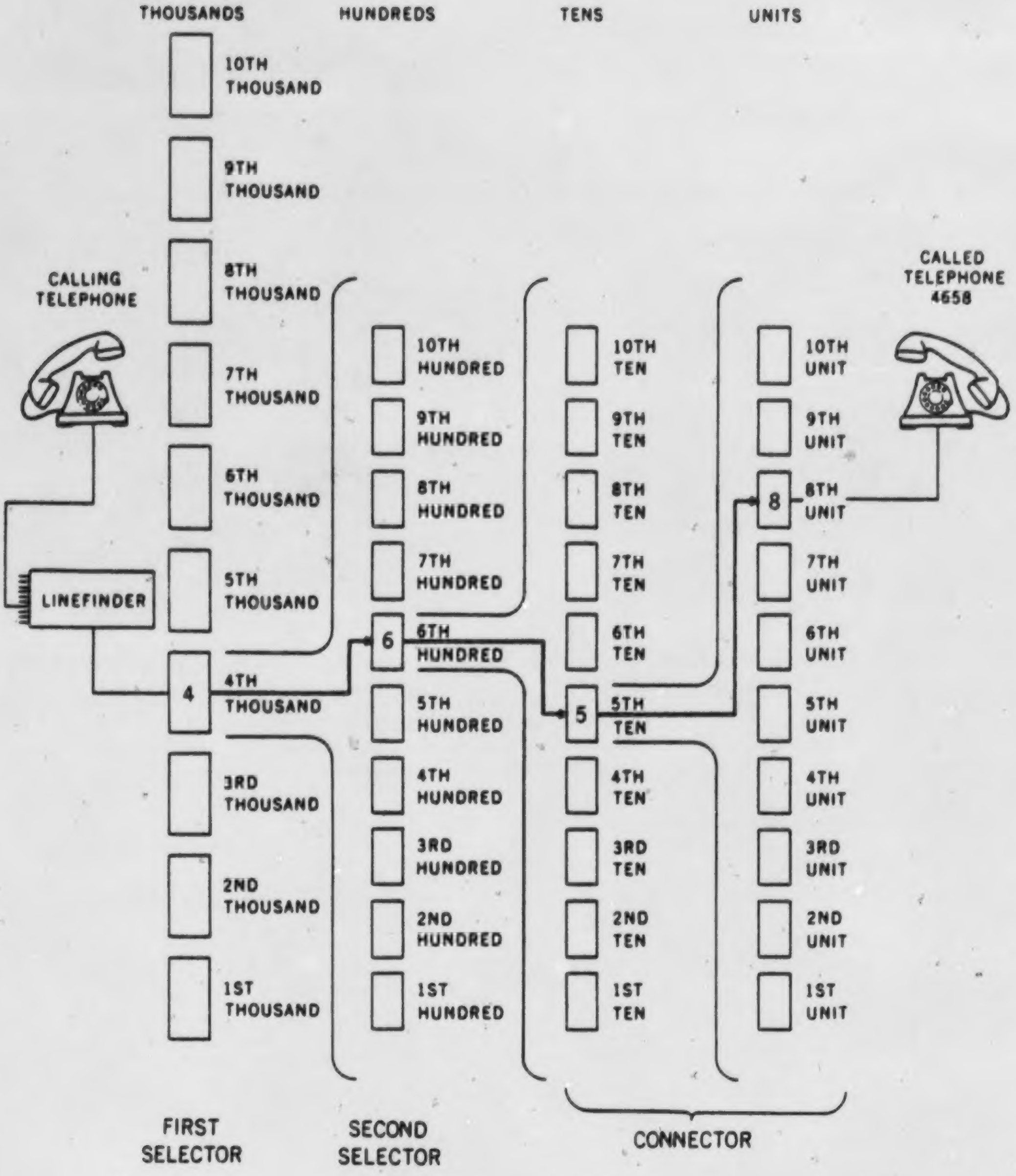


Figure 3-11. Selection by dialing in a 10,000-line system.

selector. The second selector connects between the first selector and the connectors. The directory number is also given an additional digit assignment. Dialing the first digit of the four-digit number selects the proper thousands group of telephones. This may be seen more readily if you look at figure 3-11. This illustration shows a 10,000-line system into which the number 4658 has been dialed by the calling telephone. That is, this number has been dialed after the linefinder automatically connected the calling telephone to the first selector.

When the digit 4 is dialed into the first selector of the system illustrated in figure 3-11, it selects the fourth thousands group of the 10 available. Since each first selector in the 10,000-line system has access to all the second selectors serving that specific group, dialing the 4 causes the called telephone to become 1 of 1,000 telephones rather than 1 of 10,000 telephones. Each second selector, in turn, has access to all connectors in that particular HUNDREDS group; therefore, the second dialed digit (6) causes the second selector to choose a connector of the sixth HUNDREDS group of 1,000 telephones. The called telephone is now one of a group of 100 telephones. The last two digits dialed by the calling subscriber operate the connector, thus completing the circuit that permits conversation between the calling and called subscribers. The ringing current, which indicates a need to pick up the called handset, is automatically applied to the line when the foregoing procedure is completed. Bear in mind that the called subscriber actually completes the conversational circuit by lifting that telephone handset.

Working backward through figure 3-11, you can see that a 100-line office requires only a single connector group; a 1,000-line office requires one selector group, having 10 connector groups; and a 10,000-line office requires 10 selector groups, each having 10 connector groups.

Exercises (215):

For each manual or automatic telephone system equipment function listed below, state how the same or equivalent function is accomplished by the other system.

1. A common battery subscriber in a manual system lifts the handset of his telephone from the cradle.

2. The selector(s) and connector step in response to dial pulses.

3. The actions of the connector equipment prior to returning busy or ring back tone.

4. The subscriber rerings the operator.

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CHAPTER 4

Telephone Switching Systems Installation

WHO INSTALLS the central office equipment? According to AFM 39-1, airmen with AFSCs 36251 and 36271 must install and maintain telephone switching equipment. It is evident, then, that the telephone switching equipment repairman/technician may be assigned to the job of installing central office equipment.

When telephone switching equipment is installed, certain basic principles must be followed if you are to obtain the best possible job. The first of these principles is to start with a complete, well-ordered plan for the total job. A poorly planned, hastily installed exchange may become a constant source of trouble. A well-planned, orderly installation is usually planned by qualified engineers. After the plan has been completed, it is given to the installation personnel in the form of a C-E scheme.

4-1. Installation Schemes

The telephone exchange at Somewhere AFB is operating at 95 percent of its rated capacity (1,000 lines) and many subscribers are waiting a long time for dial tone (5 to 10 minutes). Impossible you say? No, it happens every now and again; normally through poor planning or rapid changes brought about by unexpected events. In any case, one thing is obvious, something must be done to correct the problem. A scheme expanding the telephone exchange would solve the problem.

The requirement for a scheme may be for one or more of the following reasons:

(1) New installations—A telephone exchange is installed for the first time with new equipment.

(2) Expansions—Additional equipment is needed for expanding inside and/or outside plant facilities.

(3) Rehabilitation—The old system needs new parts, new equipment, or a general overhaul.

(4) Relocation—An exchange is to be moved to a new location.

(5) Removal—An exchange is to be taken out due to no further use.

216. List the parts of a C-E scheme package, describe the information contained in each part, and interpret selected portions.

A major command must originate the request for a scheme; however, the requestor may simply be a base asking through the major command. The command originates the request by submitting a CEIP (Communications Electronics Implementation Plan). EI (Electronic Installations) will furnish the technical advice and pre-engineering assistance required to prepare a CEIP. A PM (Program Manager) from the requesting command is then appointed to act as coordinator between EI and the originating command. The CEIP is then prepared with the aid of planning and programming directives, technical manuals, and other pertinent documents.

After the CEIP has been prepared, EI will indicate its agreement or disagreement on a CEIP coordination sheet. Headquarters USAF will then approve or disapprove the CEIP. They could also approve only part of the CEIP. If the CEIP is approved, a Site Survey must be made by EI. After EI makes its recommendations, a Facility Utilization Board (FUB), composed of members of all concerned organizations, must approve the site survey.

Within 30 days after the FUB meeting, EI must submit a site concurrence letter. This letter shows that everybody has agreed on the site and that the originating command has agreed to furnish support structures and allied support to EI. When the Site Concurrence Letter reaches base level, the base commander prepares a forwarding indorsement that will state what specific action is being taken to provide the support requirement. In some cases, EI might have to provide all or some of the support requirements; these services must be stated in the site concurrence letter and the reasons given why EI must perform them.

The CEIP also will determine the budgetary responsibilities. In general, AFLC will budget for equipment and materials required to install and

1·60

TAB A

SCHEME COVER
GENERAL INFORMATION SECTION
CONSOLIDATED LIST OF MATERIALS

TAB B

IMPLEMENTATION AND INSTALLATION OR REMOVAL INSTRUCTIONS IN SOW FORMAT

DRAWINGS

APPLICABLE SUPPORT DOCUMENTS

HFA-083

Figure 4-1. C-E scheme table of contents.

maintain authorized C-E-M facilities. The major commands will budget for the supporting structures and real estate.

After this procedure has been followed, EI will now take this detailed planning and write the C-E-M schemes. Please realize that the outline given you here is the procedure necessary to turn a base requirement into a C-E scheme.

All C-E schemes are prepared using a similar format, whether accomplished by Headquarters AFCS/EI or by the appropriate region. Most schemes are made up by the EI region having authority over the area where the job is located. Schemes will be prepared for all types of work on C-E facilities, whether it is a new installation or any kind of changes or repairs to existing plant. These schemes are actually detailed specifications telling the *WHAT, WHERE, WHO,* and *HOW* of installing ground electronic equipment.

A C-E scheme is divided into two main parts as shown in figure 4-1.

Tab A, logistics, consists of the following three parts:

(1) Scheme cover. This is AFCS Form 1. It is used as the front cover and also as a blank page for the back cover and binds the scheme together. AFCS Form 1 will include the scheme designer, base or station name, AFCS agency preparing the scheme, project engineer, and releasing engineer's signature.

(2) General information section. This section consists of documentation; authorizing the scheme, authorization for emergency action, a copy of any correspondence, message, or records of telephone calls resulting from coordination with the base, station, or command relating to allied construction, and copies of SCL (site concurrence letter) or SRL (support requirement letter) and support documents.

(3) Consolidated list of materials (CLM). The list of materials will be engineered in accordance with the applicable standard drawings, supplemented by current SPEL/Telephone Material List (STML) and the AFCS Illustrated Catalog. The CLM will contain only those major and minor items necessary to install a single facility or portion thereof, as required in the authorizing program document.

Tab B, scheme technical information, consists of the following three parts:

(1) Statement of work. The statement of work must include or refer to all information necessary to implement the scheme, test the facility and provide the user with interim "as installed" records. The information will be in the form of detailed instructions and make specific reference to applicable technical orders, manuals, installation standards, test procedures, etc. Maximum use will be made of AFCS installation standards. The engineer must not assume the installation team will not be able to install the scheme without detailed guidance.

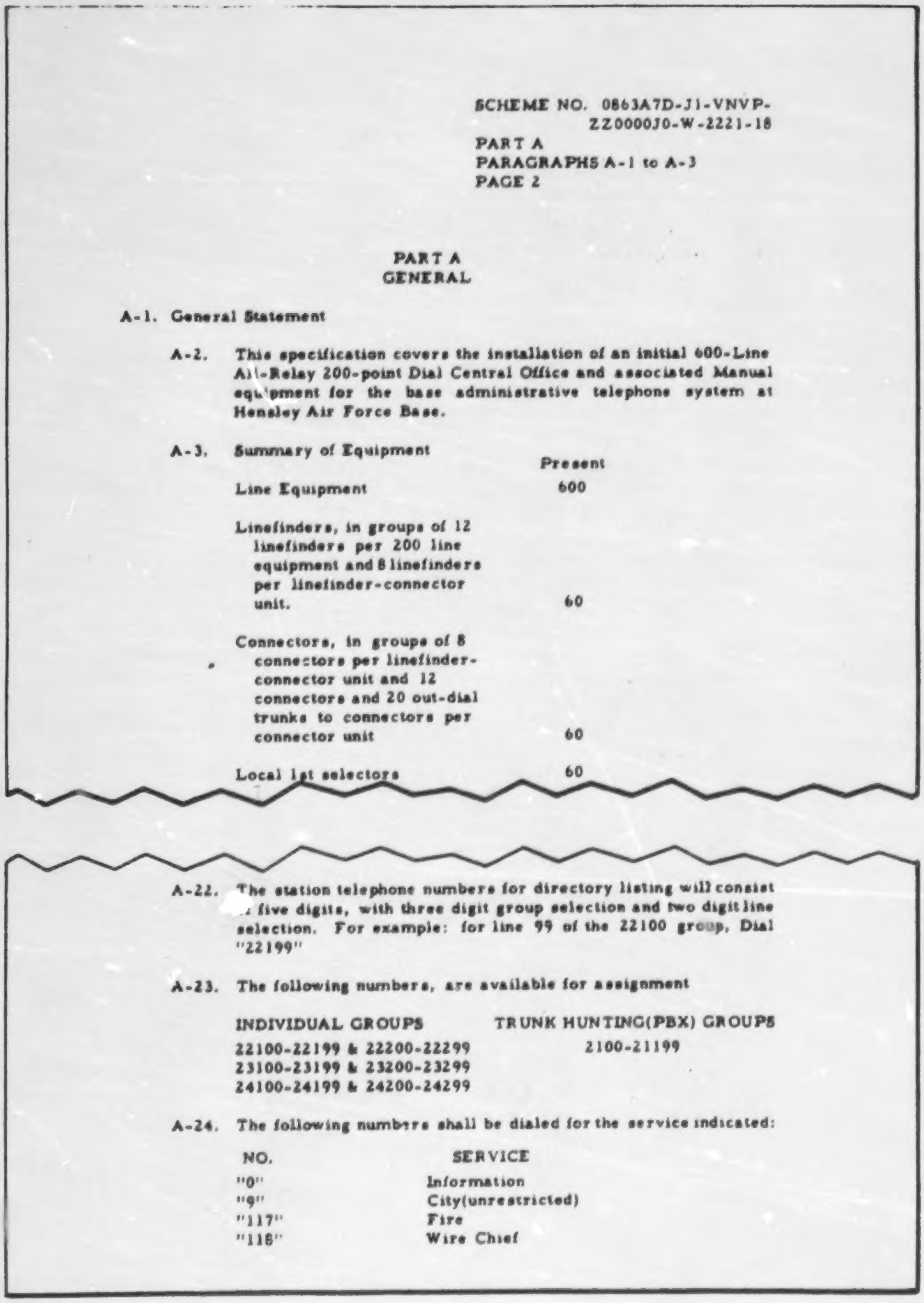
(2) Drawings. Drawings include sketches, drawings, maps, and circuit diagrams, as needed, to permit full understanding of the scheme. Use drawings rather than narrative to the maximum extent possible to convey information since they are more readily adaptable for use in plant-in-place records (PIPR). Classified drawings are distributed under separate cover when necessary to maintain the unclassified status of the remainder of the scheme.

(3) Supportings documents. Documentation considered to be of assistance but not essential for completion of the installation. Copies should be furnished or made available to the installers and be clearly marked "For Information Only."

Exercises (216):

Complete the following about C-E schemes.

1. List the two main parts of a C-E scheme.
2. Describe the information contained in the first part of a C-E scheme.
3. Describe the information contained in the last part of a C-E scheme.
4. Where is the C-E scheme in figure 4-2 to be performed?
5. How many digits will the directory numbers contain in the scheme in figure 4-2?
6. What numbers shall be dialed for the services shown in figure 4-2?



SCHEME NO. 0863A7D-J1-VNVP-
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PART A
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PART A
GENERAL

A-1. General Statement

A-2. This specification covers the installation of an initial 600-Line All-Relay 200-point Dial Central Office and associated Manual equipment for the base administrative telephone system at Hensley Air Force Base.

A-3. Summary of Equipment

	Present
Line Equipment	600
Linefinders, in groups of 12 linefinders per 200 line equipment and 8 linefinders per linefinder-connector unit.	60
Connectors, in groups of 8 connectors per linefinder-connector unit and 12 connectors and 20 out-dial trunks to connectors per connector unit	60
Local 1st selectors	60

A-22. The station telephone numbers for directory listing will consist of five digits, with three digit group selection and two digit line selection. For example: for line 99 of the 22100 group, Dial "22199"

A-23. The following numbers, are available for assignment

INDIVIDUAL GROUPS	TRUNK HUNTING(PBX) GROUPS
22100-22199 & 22200-22299	2100-21199
23100-23199 & 23200-23299	
24100-24199 & 24200-24299	

A-24. The following numbers shall be dialed for the service indicated:

NO.	SERVICE
"0"	Information
"9"	City(unrestricted)
"117"	Fire
"118"	Wire Chief

Figure 4-2. An example of a portion of a C-E scheme (objective 216, exercises 4, 5, and 6).

217. State why C-E scheme packages are inspected prior to starting work, also the method used to insure efficiency and economy of installation.

A C-E scheme, as you have seen in the preceding text, looks at everything and provides all the answers before the installation team can ask the questions. Be that as it may, the best laid plans of mice and men often go astray.

There are some things that are best looked into by the installation team when they arrive at the site.

If there is to be a minimum of interruptions during the installation, the planning has to include an understanding and an agreement between supervisors who have control of the facilities which must be available at specific times. Included among the agencies with whom consultation is necessary are the building preparation team, the utilities company, the outside plant organization, and the base materiel unit. The construction or repairing agency must have the building in good condition before any installation is attempted, because the equipment cannot be disturbed after it is in place. Also, dust, smoke, and moisture must be held to a minimum in a central office; thus, no work which would provide these elements is to be permitted after the equipment is installed. The utilities firm must have AC power connected into the building and an ample number of convenient outlets in working order. The overhead lighting must meet the specifications established for all central offices. Ventilating, air-conditioning, and heat must also be provided prior to beginning the installation. The outside plant personnel should have the cable vault constructed and the cabling in place. The materiel section will have to get tools, workbenches, cleaning equipment, shop shelving, filing cabinets, and other necessary building furnishings.

By checking the tasks to be done and the order in which they must be done against the prerequisites discussed above, you may find that you do not have to wait as long as you thought in order to start the job. type of careful study may save your team time and effort; by allowing you to do certain portions of the installation prior to completion of work by civil engineers or some other agency.

Exercises (217):

1. Why should schemes be inspected prior to the start of the work?

2. What method is used, while inspecting the scheme, to insure efficiency and economy of installation?

4-2. Equipment Placement and Securing

This part of the text describes the preparation of central office floor plans. We will discuss the factors which determine the positioning and securing of equipment. The engineer must consider the following in preparing a floor plan:

(1) The relative placement of equipment units should allow for the shortest possible cable runs.

(2) Allow for expansion of the office without rearrangement of equipment or interruptions in service when equipment is added and cut over.

(3) Space should be allotted for future equipment in each line up so that equipment will be grouped with its own type.

(4) Adequate clearance must be provided on cable racks for present future cables.

218. Explain how reference lines are established.

When the floor plan drawing is complete it will show the exact placement of all equipment. Brass markers, known as floor markers, should be located and fastened in place at the time the building is constructed. The markers provide a two-way alignment for providing the installer with a positive means for locating the equipment.

Where floor markers exist, reference lines shall be established to intersect at right angles at the point where the markers are located. These reference lines are designated "A-A" and "B-B."

However, if floor markers do not exist, the installer may establish a reference line parallel to the longest unbroken wall of an equipment room. All other measurements for equipment layout markings are made from the reference line. Measurements taken from random points along the same or different walls within a room will vary to such a degree that the equipment will not line up properly.

The reference lines should be placed on the floor with a chalkline aligned at the centers of reference plugs. Where reference plugs are not provided, the line may be laid parallel with the wall by either of two methods.

Level and Square Method. Place the square upright on the floor with the longer side parallel to the wall and butt the end of the shorter side against the wall. Lay the level along the side as shown in figure 4-3A and shift the square until it is plumb, but still in contact with both the wall and floor. Make a suitable mark at the point of contact between the floor and bottom of the inner edge of the square. All marks made in this manner will be 14 inches from the wall.

Plumb Bob Method. Place the longer side of a square against the wall approximately 3 feet above floor level. Plumb the square with a level as shown in figure 4-3B. Drop a plumb line from the short side of the square as illustrated, and mark this point on the floor. Be certain that the plumb bob is hung from the same point of the square for each succeeding operation.

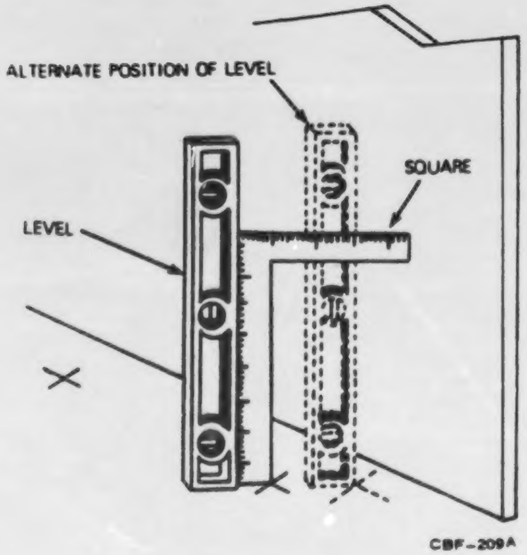

Figure 4-3A. Level and square method.

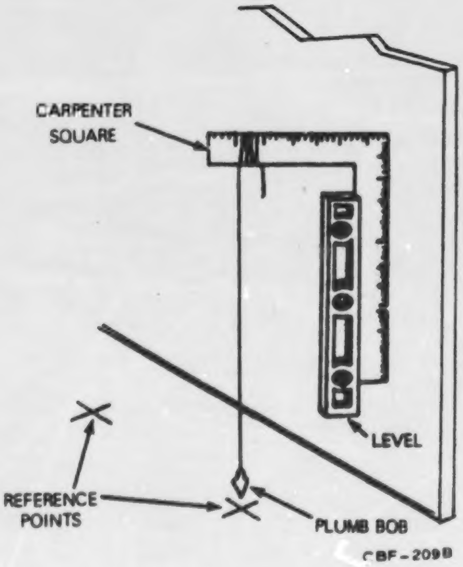

Figure 4-3B. Plumb bob method.

Perform the marking operations in at least three locations, one near each end of the wall and the third near the center. The more locations marked, the better will be the chance of detecting deviations in the wall.

After the points have been marked, stretch a chalkline to intersect them and snap the line on the floor. When the references points are not directly in line due to variations in the wall structure, locate the chalkline to intersect the greater number of points, including those at either end, where possible.

A base line is one upon which the equipment is directly aligned. It may be placed at the front, rear, side, or as a centerline for the equipment. The centerline is usually indicated by C on floor plan drawings. Base lines may be required to be laid either parallel or perpendicular to the reference lines. Methods of accomplishing this are thoroughly covered in TO 31-10-9.

Exercises (218):

1. When floor markers exist, how are reference lines established?

2. When floor markers do not exist, how are reference lines established?

219. List the steps for laying out floor angles.

Floor angles for switching equipment frames are furnished in the required lengths. The mounting holes in floor angles are predrilled. The simplest method of marking of the mounting holes centerline is to place the floor angles on their vertical face lines and mark the floor at the mounting holes (see fig. 4-3C).

The procedure for installing floor angles is to drill the holes in the concrete floor in the designated locations as follows:

(1) Use an electric drill or star drill and hammer. Be sure to use a drill point suitable for concrete. WARNING! *Always wear goggles when drilling concrete to protect your eyes.*

(2) If the hole is more than ⅜ inch diameter, drill a pilot hole with a ¼ inch drill. Use a drill of proper diameter to obtain the final size of the hole. The pilot

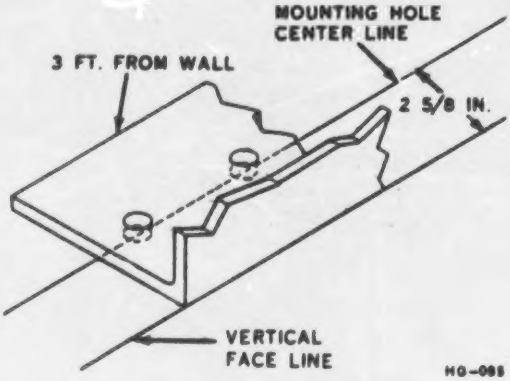

Figure 4-3C. Relationship between vertical face line and mounting hole centerline.

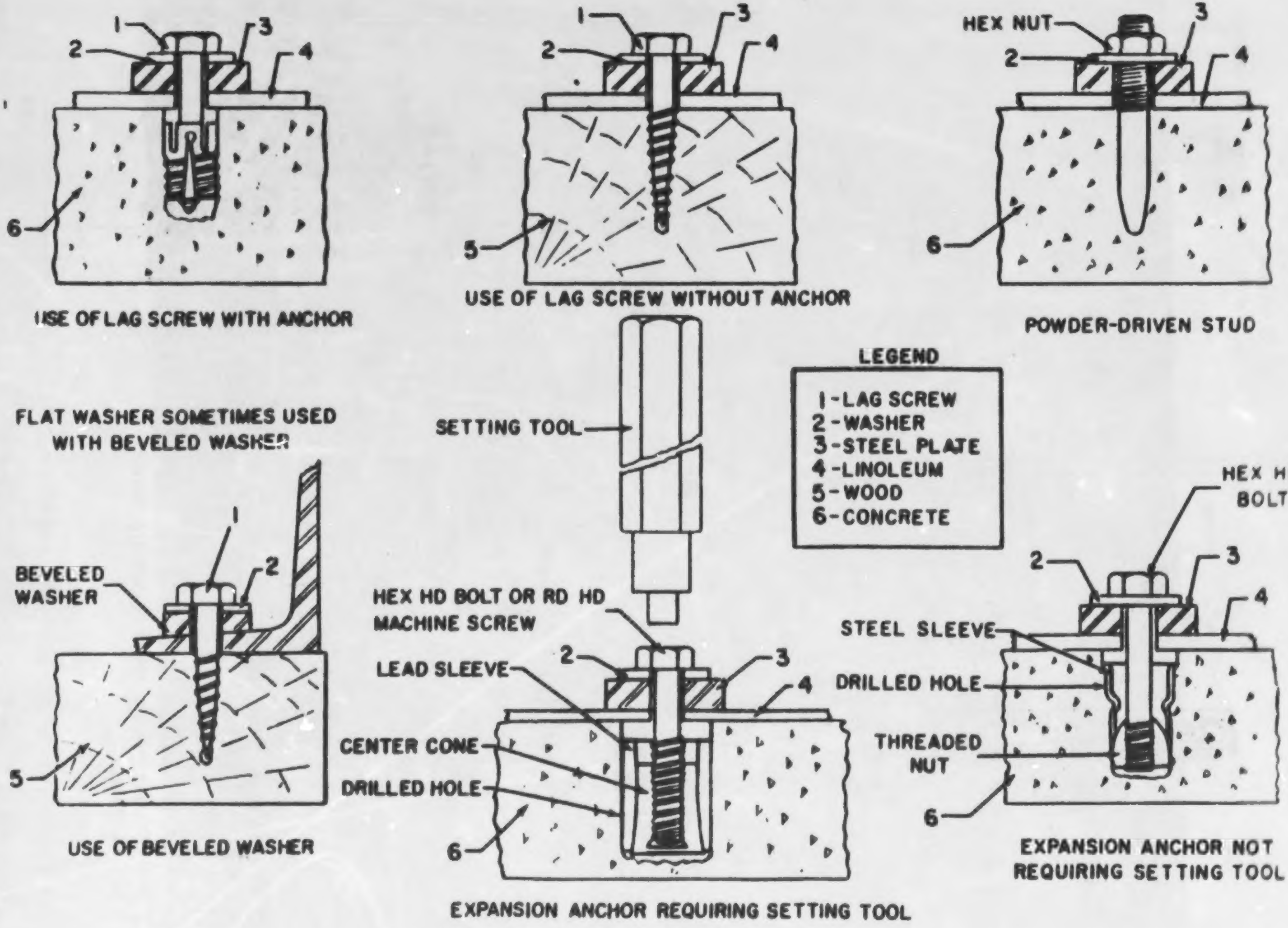

Figure 4-4. Floor fastening devices applied to various floor materials.

holes prevent the drill from "drifting" from the hole centers. The length of the hole should be ¼ inch deeper than the size of the fastening device it accommodates. In other words, if the fastening device is 1½ inches long, drill the hole 1¾ inches deep.

(3) Use a vacuum cleaner to clean out the concrete dust during and immediately after drilling process.

(4) Holes may be drilled in wood floors with either hand operated or electrically driven tools.

(5) Insert the fastening devices (expansion anchors or shields) if they are to be used before installing the floor angles. Figure 4-4 illustrates a variety of anchor methods in different types of floors.

(6) Place the floor angles on the vertical face lines and fasten each floor angle loosely in position until an entire line has been laid out.

Stretch a piece of string across the vertical faces of the angles to check for proper alignment. Tighten the screws or bolts only after perfect alignment and levelness are observed. To build up the floor angle at low level areas, use light metal shims the width of the floor angles and at least 4 inches long. To level off high spots, cut out as much linoleum as is necessary under the floor angle. It may be necessary to chip the concrete floor to achieve desired leveling. Also, remember each row of floor angles must be level with each other.

Exercises (219):

1. State, in proper order, the steps for installing floor angles.

2. What hardware is required to connect a small cable rack to a large one?

3. What standard lengths does cable rack come in?

4. What standard width does cable rack come in?

220. List the steps for installing ladder-type cable rack for specified situations.

Cable runways are used to support the wires and cables that connect the equipment in your central office. You tend to take cable racks for granted, as well as the rest of the equipment that make up your exchange. At this time we cover the basic procedure for installing cable rack.

Placement and Supports. Cable racks are installed where the cable rack assembly drawing shows that they are supposed to be installed. The floor drawing shows the location and the length of each of the cable racks. Before you can install cable rack, all of the frames, wall angles, and permanent bracing must be installed, and should be level and plumb. After all, cable rack is not supported by sky hooks, although ceiling hangers come close.

After checking the cable rack assembly drawing for the location, check the cable rack furnished for the job against the job drawing to determine the most economical use of the rack.

Installation Procedure. The first thing you must do is to select cable rack of the proper width. In tech school you were taught that cable rack comes in five widths: 6, 9, 12, 18, and 22 inches in width and in standard lengths of 5 and 10 feet. This

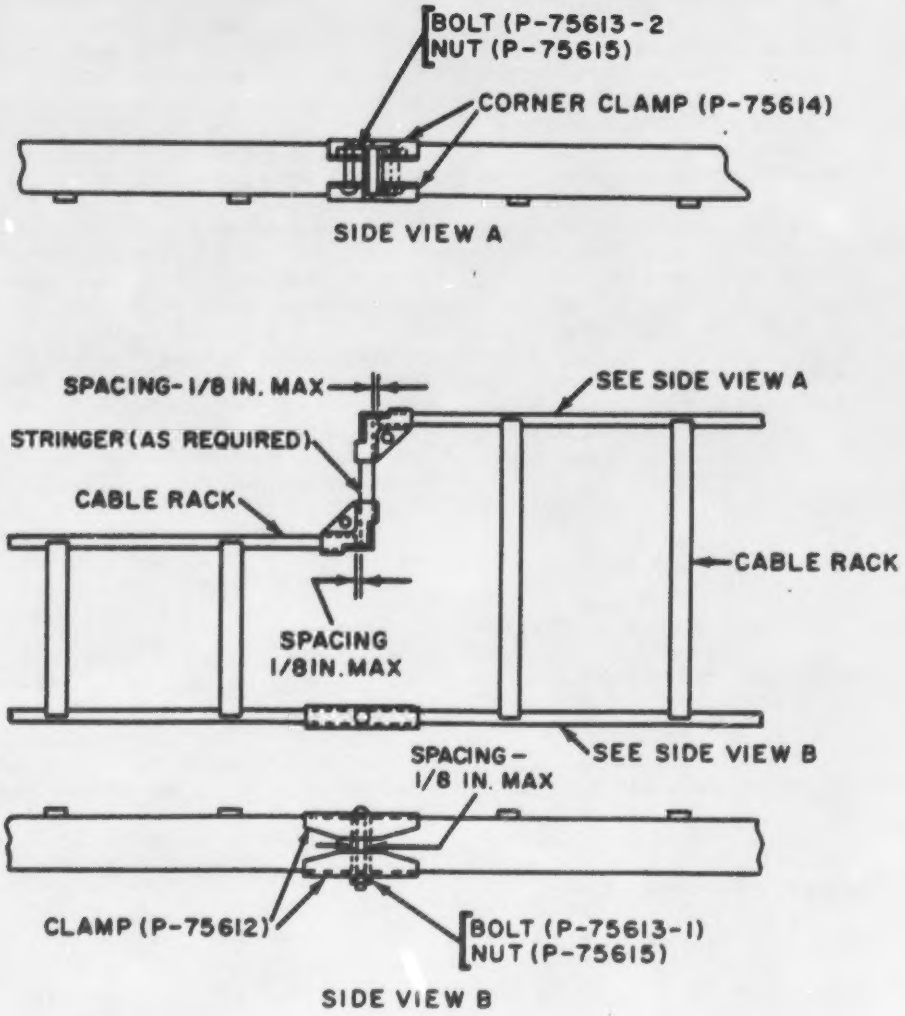

Figure 4-5. Clamping smaller rack to larger rack.

information is found in the cable rack assembly drawing.

Once you have a length of cable rack you place it on top of the channel bracing and secure it using J bolts, clamp plate, lock washers, and nuts.

The next step is to place another section of cable rack on top of the channel bracing and join it to the preceding section using straight clamps, nuts, and bolts. Secure the second section to the channel bracing with J bolts as you did the first section. This continues until the cable run, as shown in the drawing, is complete. You must be sure that the cable run is level over its entire length.

When a cable rack must branch away from the main cable rack run you must select the proper width and length cable rack. Corner clamps are used to join the branch cable rack to the main run. The procedure for installing the branch cable rack is the same as that used on the main cable rack run.

When you must change cable rack sizes in a given run, you use corner clamps and stringers or side bars, see figure 4-5.

If you encounter a situation where pipes or ceiling construction get in the way of a cable run, you use an offset arrangement which allows you to lower the height, when branching out to another equipment row, across an open space when channel bracing is not used to support the cable rack. The 45° clamps, nuts, bolts, and the proper short lengths of cable rack are used to do this.

It should be obvious that no one standard procedure holds true when installing cable rack.

This much, however, does hold true. You use the cable rack assembly drawing which shows where the cable rack runs are to be installed; it also indicates the width of the cable rack to use and the length of the cable run.

When channel bracing is used to support the cable rack, J bolts are used to secure the cable rack to the channel bracing. Straight clamps are used to connect lengths of equal width cable rack together. Corner clamps are used to connect the cable rack, for branch cable runs or turns, to the main cable rack run. An offset arrangement is used to lower or raise the height of a cable run when necessary due to ceiling construction or obstructions such as pipes or conduit in the path of the cable run.

Tech Order 31-10-6, *Cable Racks, Troughs, and Their Supports*, outlines the various procedures used for particular situations and instructions on how to do it. This should be used any time you have to install cable rack.

Exercises (220):

Read the narrative below, and then answer the questions about cable rack installation.

Twelve-inch wide, ladder-type cable rack is to be installed above four selector bays with a cable rack connection at one end. Selector bays 101 and 102 are on the opposite side of the aisle from bays 103 and 104. The total length of each run is 30 feet long and the aisle is 4 feet wide.

1. What is the first step you will take?

2. What is the second step (bays 101 and 102)?

3. What actions follow the second step in bays 101 and 102?

4. What is done when the cable rack above bays 101 and 102 is completed?

5. What is the next step once the cable rack installation above the four selector bays is complete?

4-3. Central Office Cable Installation

The cable routing for every installation, regardless of size or whether it is the original installation or an addition, should be planned well in advance of the cabling operation. The plan may be outlined in the specification or may be completely drawn up on the job. The planned cable route need not be the shortest distance between two pieces of equipment, but should be planned to limit pileup, minimize crossovers, and present a good appearance.

221. Given a statement outlining the installation of cable, state the order and method of running the cables and the ties and stitches to be used at specified locations.

Station ground and power cables have rubber covering over stranded or solid copper conductors. Power cables can be lead covered. Station ground cables are used to provide a main point of DC return for a central office while the power is on.

Switchboard cable consists of several conductors bound into one or more grounds which are covered with a common sheath. The sheath may be of either fabric or plastic. The common sheath or covering offers protection to the conductors and keeps out excessive dirt or moisture. The term switchboard was originally applied to its principal use and has been retained, although the application of the cables has been greatly expanded.

Paired wires or jumper wires are insulated conductors twisted together without a sheath or outer covering. These wires are used to make miscellaneous or temporary runs between equipment.

Running a cable is placing it on a cable rack or other support from one termination point to another.

There are six different types of cables in present use and these cables must be placed on the cable rack in a specified order:

Sequence	*Cable Type*
1	Station Ground Cables
2	Power Cable and BX, BXL, etc.
3	Lead Covered Cable
4	Switchboard Cable
5	Coaxial Cable
6	Miscellaneous Small Cables and Wires

You will seldom, if ever, find all the types of cable in one exchange, but the running order is maintained. The purpose of having a running order is to insure that the heavier and sturdier cables are kept on the lower levels rather than piled on lighter, more fragile cables. The permissible height to which layers of cable may be piled on cable racks, troughs, or trays, is generally considered to be a distance equal to the width of the runway, but not to exceed 12 inches. The height of the layers of cable is shown in the installation scheme.

Some items to be considered when planning cable runs are as follows:

(1) Number of cables to be run.

(2) Types, codes, sizes, shapes, and lengths of cables.

(3) Location of breakoff points of cables from racks to equipment.

(4) Allowance for the placement of additional cables on future jobs.

(5) Intersections and junctions of cable rack.

Preparation. Before starting to run cable, inspect the cable runways for rust or scratches. Remove the rust and touch up the framework with matching enamel. Place personnel at all bends, turns, and points of contact to guide the cable and prevent the sheathing on the cable from being marred.

Unless all safety precautions and practices are strictly followed, running cables present hazards to the installer, equipment, and cable. The following general practices will aid in minimizing hazards as well as expediting the running operations:

(1) Do not leave cable reels unattended while cable is being run.

(2) Run only as many cables as can be handled conveniently at one time.

(3) Locate reels in a manner which prevents cables from rubbing on adjacent reels or stands.

(4) To keep waste to a minimum, check the length of the cable on the reel against the total footage of the type to be run and plan accordingly.

(5) Do not cut cables to the lengths shown in the cable running list. Run the cables first then cut them.

Cable Tags. Cable tags are used to identify or mark the cable to be run. These cable tags may be supplied in sheets of six or in pairs. Carbon paper is inserted between them so they can be made out in duplicate since two tags are required for each cable. Information to be filled in on the cable tags is usually obtained from the cabling section of a specification or a job cable running list.

Cable Running. The reel attendant should keep twists out of the cable between the reel and the cable rack. The members of the crew will be responsible for their assigned areas. This eliminates the necessity of untwisting the entire length of the cable when the run has been completed. It will also protect the cable sheath and the insulation of the conductors from damage.

The reel attendant should prevent excessive strain on the cable by turning the reel by hand. To prevent the reel stand from tipping over should excessive pull be exerted, unwind the reel from the bottom side. Place the reels on heavy cardboard or plywood to avoid damage to the floors.

When the cable has reached the piece of equipment in which it will terminate, pull in enough additional slack to allow for forming and wiring. Tie the cable in place temporarily at all turns and bends where they tend to slip off the side of the runway.

Tie the second cable tag at the appropriate location of the butt and cut the cable.

Ground and power cable. Reels of ground and power cables are usually larger and heavier than the other types of cables. They are ordinarily supported for running cable by jacks or by roller-type supports.

Ground and power cable tend to maintain the coiled shape of the cable reel and must be shaped or formed to straighten them as they are being run.

Do not drag armored power cables across the cable rack as the metal covering will scratch paint and expose the rack to rust and oxidation.

When a run of ground or power cable is completed, cut the cable with either a hacksaw or boltcutters. Cable shears are not designed for heavy work.

Switchboard cable. When running switchboard cable, place the reel in an A-type frame. Inspect the plastic or fabric sheath of the cable for tears or abrasions as it is being run. Handle it carefully to avoid damage.

Wires. Tag and run the miscellaneous wire in the same general manner as cables. Since these wires are smaller than cables (usually one to four conductors) they tend to tangle and spread across the runway. To keep the wires reasonably straight while running, place wire loops temporarily on the threaded rods or on the runway at intervals of 8 to 10 feet and at all turns and bends. Run the miscellaneous wires through the loops until enough are accumulated to be sewed down. Miscellaneous wires are usually supplied on small metal reels. A good method for holding these reels is to insert a metal rod in the center of the core. Then the wire can be pulled off very smoothly.

Lacing Cables. The preferred method of securing cables to the cable rack is lacing them with waxed number 12 cord. Lace the cables to the cross straps using the starting stitch, Kansas City stitch, and ending stitch (Hawthorne knot). Other special purpose ties, such as the banding tie, are sometimes required for single cables or large heavy cables. Secure the cables and wires to cable racks at every second cross strap unless otherwise specified.

Exercises (221):

Use the narrative below, as necessary, to complete questions about running cable.

For the installation of an additional row of selectors (two bays) and a grading terminal assembly (GTA) in an existing XY telephone exchange, the following listed cable had to be run. The cable rack used is 12 inches wide. A power cable, 20 lengths of switchboard cable, a ground return cable, and 10 lengths of small wire.

1. In what order is the cable listed above to be run?

2. List two methods of running power cable.

3. What are the cables laced to, after they have been run?

4. What three stitches are used when sewing a form?

222. List the color code for the standard 20.

The insulation of the conductors of a cable is usually color coded to determine selection of the colored conductors. Switchboard cables have color coded conductors. Color coding may or may not be used for the conductors of a lead covered cable.

CONDUCTOR NO.	COLOR
1	Blue
2	Orange
3	Green
4	Brown*
5	Slate
6	Blue-White
7	Blue-Orange
8	Blue-Green
9	Blue-Brown
10	Blue-Slate
11	Orange-White
12	Orange-Green
13	Orange-Brown*
14	Orange-Slate
15	Green-White
16	Green-Brown*
17	Green-Slate
18	Brown*-White
19	Brown*-Slate
20	Slate-White

*In some cables, black is used instead of brown

Figure 4-6. Color code for standard twenty.

Use of the color coding system eliminates the necessity of making continuity tests in order to select particular conductors. The coding system employed is dependent upon the type of insulation used, the number of conductors in the cable, and whether the conductors are arranged as singles, pairs, triples, or quads. Cables most frequently used have either cotton and silk or polyvinyl chloride insulation on their conductors.

Cables having a relatively large number of conductors make use of a basic color code consisting of five colors—blue, orange, green, black, and slate. Use of this code provides 20 combinations which are illustrated by number and abbreviation in figure 4-6.

The color coding established for single conductors that have cotton and silk insulation permits the distinguishing of as many as 60 single conductors. The first 20 conductors are identified by means of the basic color code shown above in figure 4-6. The second set of 20 conductors are identified by the basic color code plus a black tracer. A tracer is a thread of contrasting color woven into the insulation of a conductor to permit distinguishing that conductor from another having the same basic color. The third set of 20 conductors is identified by the basic color code plus a red and black tracer.

A cable containing 60 single conductors may also contain a ground wire (black insulation) and as many as four spare single conductors. Spares 1 through 4 have insulation which is colored red and white, black and white, red and black, and red, black, and white respectively.

Usually, 1 spare pair is provided in a cable having up to 100 pairs and 2 spare pairs in a cable having between 100 and 200 pairs.

The ring conductors of triples (three conductors) of a cable are identified using the basic color code shown in figure 4-6. Insulation of the mate (tip) conductors of triples is colored white, while the third set of conductors (sleeve) is identified by red insulation. Colors used to identify the conductors of a spare triple are black (ring), white (mate or tip), and red (sleeve).

A spare quad has its first pair of conductors colored red (ring) and red and white (mate); its second pair is colored black (ring) and red and black (mate).

Exercise (222):

1. List the color code for the standard 20.

223. State the termination requirements for solder and wire wrap terminations.

Butting and Stripping. Butting and stripping cables are necessary to remove a sufficient amount of sheathing or outer insulation from cables to permit access to conductors for forming and terminating operations. Methods of butting and stripping vary and are dependent upon the outer covering of the cable and additional wrapping such as braided metal, flexible armor, or lead sheathing. Butting is the term used to describe the operation of making a circular cut through the covering or sheath of a cable at the point where the outer insulation is to terminate.

"Stripping" is the term used to describe the operation of making a lengthwise cut in the cable covering from the butting point to the end of the cable. Stripping also includes removing the outer covering and inner wrappings to expose the inner conductors for forming and for terminating operations.

Fanned Forms. A fanned form is a group of conductors that originate at the butt of a cable or at a corresponding point along the sewed portion of the cable form, travel through a fanning device, and end at equipment terminals.

The fanned forms permit maximum access to the equipment for maintenance or troubleshooting. In addition, it also permits freedom of movement of the equipment and does not interfere with the installation or operation of any removable or movable parts.

The conductors are fanned through the fanning ring on the side where the equipment wiring is located. The equipment side is usually called the local cable and is found on the left side of a vertical terminal block or on the bottom side of a horizontal terminal block.

For ease of handling and fanning, conductors may be cut off about 6 inches beyond the face of the extreme front edge of the terminal strip.

Care should be taken to insure that the pairs of conductors are not separated while handling.

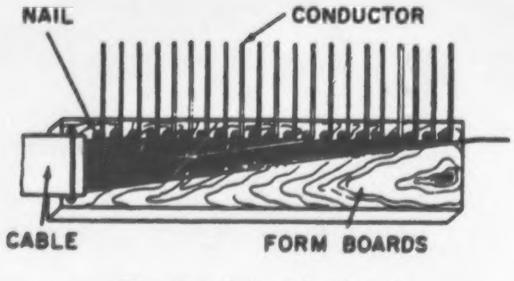

Figure 4-7. Nail-type form board.

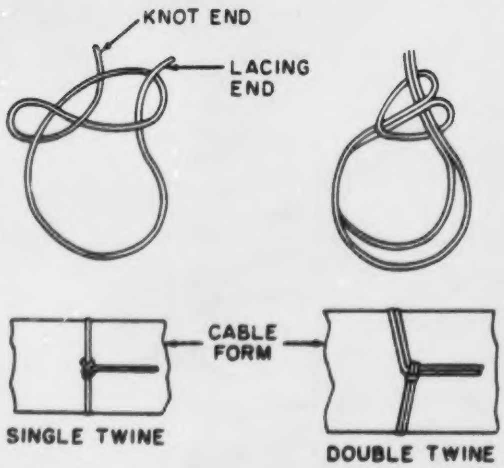

Figure 4-8. Formation of the starting switch.

Horizontal fanned form. On the horizontal side of a main distribution frame a cable can fan out to no more than five terminal strips. The leads of miscellaneous cables may be fanned over a maximum of 10 terminal strips.

Vertical fanned form. On the vertical side of the frame a cable may be fanned over the entire vertical or over any portion but never over more than one vertical.

When the cable conductors are spread over a group of terminal strips, the cable is butted on the horizontal brace of the frame (transverse arm) approximately at the center of the group of terminal strips.

The spare wires are the extra wires placed in the cable. They are used in cases where, through breakage or other unusual causes, some of the regular wires in the cable are not available for use.

At the terminal strips equipped with a fanning device, the spare wires are brought through the farthest fanning strip hole from the butt of the cable. The wires are then cut approximately 1 1/2 inches past the face of the clamping strip and bent toward the cable butt and extend through a hole and allow 1/2 inch of wire beyond the fanning strip.

Unequipped wires at terminal strips having fanning devices shall be treated the same as spare wires. Where the wires are in excess of the number that can be fanned through one hole, they may be placed in a phenolic tube and secured to the form.

The unused wires are regular wires in a cable, other than spare or unequipped wires, which are not required for future use and which are generally treated as spares in the form. The unused wires of a cable are used in preference to the spare wires when leads in a cable have to be replaced.

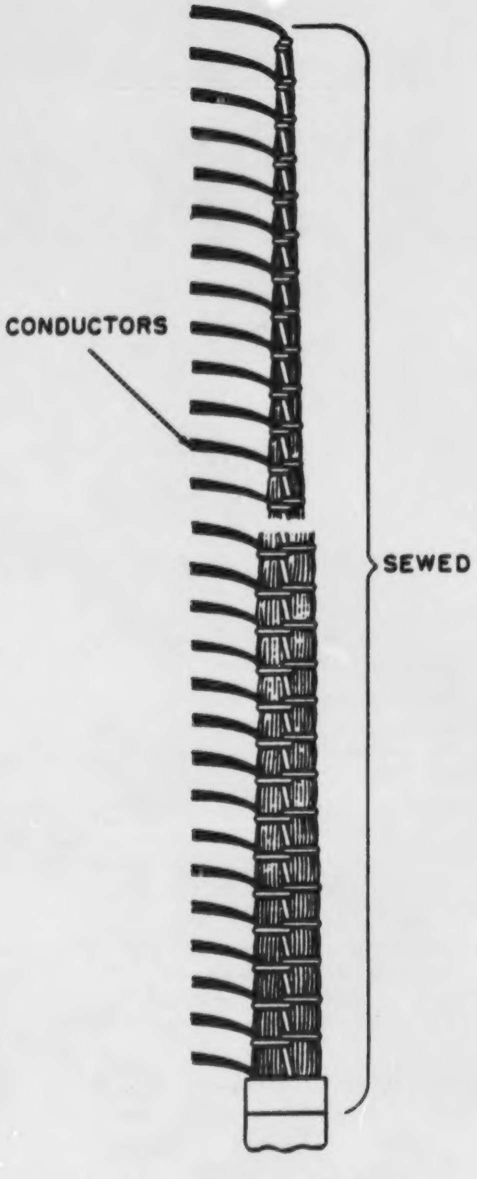

Figure 4-9. Typical sewed cable form.

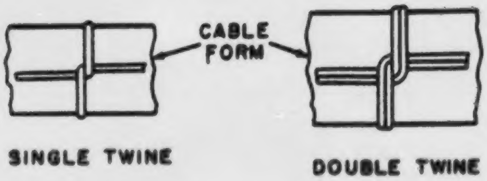

Figure 4-10. Formation of the lock stitch.

Sewed forms. A sewed form is an arrangement of cable wires compactly laced in such a manner that the wires are brought out approximately opposite their associated equipment terminals. Sewed forms are used for local switchboard, lead-covered, and other types of multiconductor cables which terminate at equipment lacking fanning devices.

Sewed forms follow the contour of the framework. All bends, wire breakouts, and skinner lengths are predetermined before the forming operation starts. All bends and arms are made while forming.

The position of the wires in the form are kept straight to keep the wires from crossing one another. If crossing is necessary, make the cross over the greatest distance possible.

Form boards are constructed on the job. They are used to shape the conductors of a cable when laying them out prior to sewing. Form bodies are of three main types: hole-type, notch-type, and nail-type. Figure 4-7 shows the nail type.

The materials that are used for the form boards should not produce dirt, lint, or any residue that is detrimental to nearby equipment. Some suitable materials are plywood, fiber board, or wire mesh (1/4 to 1/2 inch).

The form is sewed with approved sewing twine or cord. If the maximum diameter of the main form is less than 3/8 inch, a single strand of number 6 twine is used. If the maximum diameter of the main form or branch arms is not greater than 1 1/2 inches nor less than 3/8 inch, a single strand number 12 twine is used. Where the main portion of the form is greater than 1 1/2 inches in diameter, use doubled number 12 twine. Twine of two different sizes is not used on the same form.

The knots of the stitches are placed on the side of the form nearest the equipment served.

With the single leg form, a starting stitch (see fig. 4-8) is made as near the butt of the cable as possible (see fig. 4-9). Now, with the lacing end of the twine

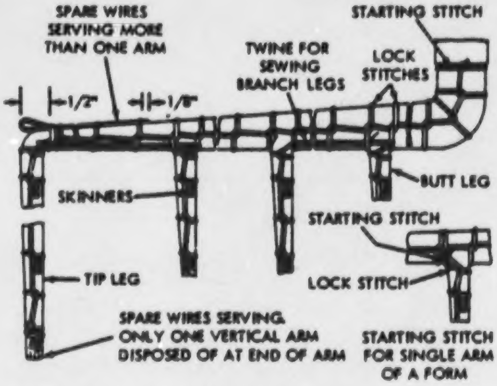
SPARE WIRES SERVING MORE THAN ONE ARM
STARTING STITCH
TWINE FOR SEWING BRANCH LEGS
LOCK STITCHES
1/2"
1/8"
SKINNERS
BUTT LEG
STARTING STITCH
TIP LEG
LOCK STITCH
SPARE WIRES SERVING ONLY ONE VERTICAL ARM DISPOSED OF AT END OF ARM
STARTING STITCH FOR SINGLE ARM OF A FORM

Figure 4-11. Multileg form with vertical branch legs.

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(see fig. 4-10), a lock stitch is used on each breakout point of the cable pairs (see fig. 4-11).

The ending stitch consists of two lock stitches placed close together in place of the regular single stitch. It is located where the last conductors break out of the form.

The multileg form is sewed with the starting stitch as near to the butt as possible, With the lacing end of the twine, start the locking stitches. They are made at intervals of approximately 2 inches on the portion of the form that has no branch arms or breakouts. A lock stitch is placed at each breakout point, at each bend, and at the beginning of branch arms. These stitches continue until the farthest point of the form is reached.

Additional twine of sufficient length is sewed into the form. This additional twine is later used to sew the branch legs. At the end of each leg the ending stitch is used.

Where cables are sewn into a form, the spare, unequipped and unused wires should be at least as long as the longest wire in the form.

On a single-leg form, the spare, unequipped and unused wires should be brought out to a point approximately 1/2 inch beyond the face (tip) of the form, doubled back along the equipment side of the form and sewn into it. The free ends of these wires are cut off 1/8 inch beyond the regular stitch which secures and is nearest the ends of these wires.

On a multileg form, the spare, unused and unequipped wires serving all of the arms are to be doubled back on and sewn into the equipment side of the horizontal arms. A cable serving only one arm of a multileg form shall have their spare, unequipped and unused wires cut to the same length as the longest wires of that arm and sewn into the arm.

After the sewing operation is completed, the forming board is cut loose and you prepare to terminate the conductors.

Terminating. Terminating involves stripping the insulation from the conductors, placing the conductor in or on the proper terminal, and securing by wire wrap or soldering.

Soldered connections. The American Welding Society defines soldering as a joining process wherein combining or blending is produced by heating, and by using a metal that has a melting point below that of the base metal. The melted solder is distributed between and around the properly fitted parts. This type of soldering is also known as "soft" soldering in order to separate it from silver soldering, etc., known as "hard" solder which requires higher heat.

When molten solder forms a continuous, unbroken film on a metal surface, it is said to "wet" the surface. Wetting can be explained in the following way: If a drop of water is placed on an oily surface, it will retain its original shape and will not spread, it does not wet the surface. If a detergent

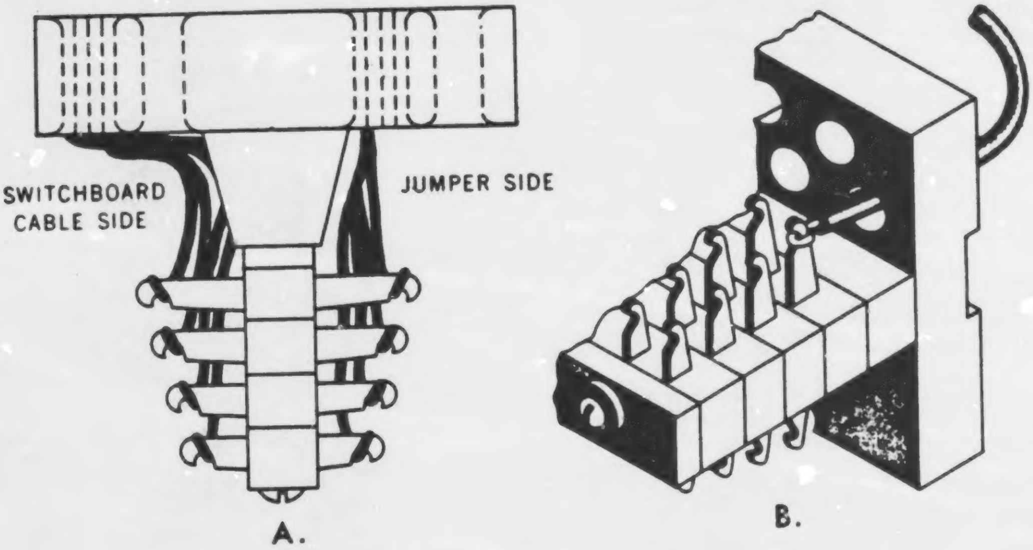

Figure 4-12. Single notched terminals.

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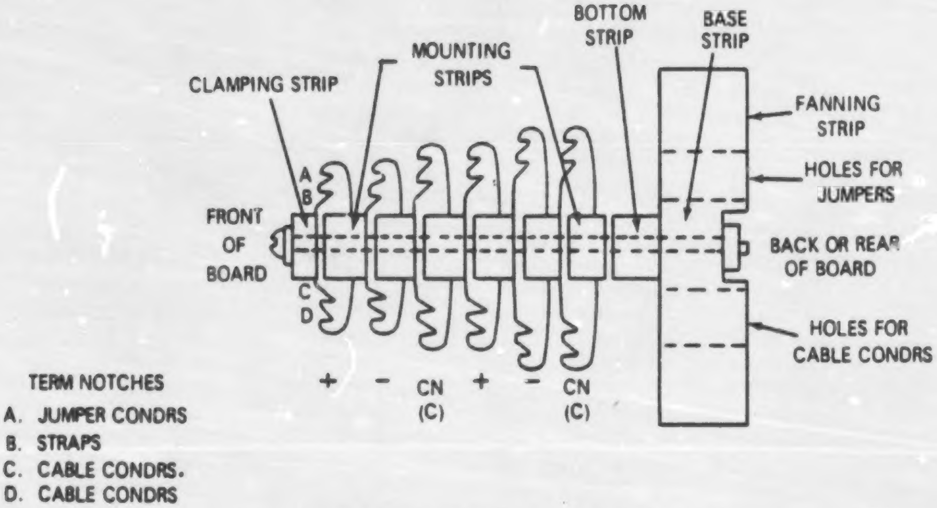


Figure 4-13. Double notched terminals.

or some other wetting agent is added to the water, a drop of this mixture will spread and wet the same surface. Solder will wet some metal and not others. Soldering is achieved through wetting.

The temperature range between solid and liquid is called the pasty or plastic range. In this range, the consistency of the solder is soft or slushy. The smaller the plastic range, the less chance of bad or cold connections caused by movement of the wire or terminal and the quicker the job can be finished and returned to service.

The Air Force and industry has selected a solder having 60 percent tin and 40 percent lead as being the nearest standard solder to the ideal. It has a plastic range of only 13°; it is as nearly ideal as could be expected from a standard shelf item.

The primary function of a flux is to prevent the formation of oxides on metallic surfaces while they are being heated for soldering. Fluxes have some cleaning ability; however, they should not be expected to remove heavy surface oxides, paint, or dirt from metals. Such oxide or residue must be removed by mechanical or chemical cleaning processes.

The traditional soldering tool is the conduction soldering copper or iron with a copper tip. It can be heated by an external flame or by a more conventional electric element. Copper tips are used because copper has a high heat conductivity and readily allows heat to flow from heating element to its tip. In addition, copper tips tin easily. Tinning is the process of protecting the soldering iron tip from tarnish and corrosion by means of a thin coat of solder applied to the tip. This way, the iron can transmit heat most efficiently to the joint being soldered.

Soldering irons must be selected to fit the particular soldering operation because numerous types are available in a wide variety of sizes, shapes, and ratings. Whereas many soldering irons are general purpose tools, others have been developed for specific types of soldering. The size and shape of iron needed depends on the size and shape of the joint, the speed of soldering required, the solder melting temperature, and space limitations.

Electric soldering irons are rated in watts according to their capacity. Although the actual size of the soldering iron is related to its wattage rating, two irons may maintain the same tip temperature even though their size and wattage may be quite different. A major point to be considered in the selection of a soldering iron is the size of the joint to be soldered.

Most electrical soldering irons are designed to be used with several tips. The pyramid, screwdriver, and chisel are the most common shapes of tips, but other tips are available for special applications. Tips vary in lengths and diameter. Copper tips oxidize rapidly at temperatures over 750° F. and become rough and pitted. To maintain their soldering efficiency, copper tips must be tinned frequently and shaped or dressed by filing when necessary.

Notched terminals consist of flat metal strips shaped at the end to receive conductors and hold them in place mechanically until soldered. Several variations in the type of notches encountered are illustrated in figures 4-12 and 4-13. Notched terminals are usually strip mounted, the entire assembly being commonly called a *terminal strip* or *terminal block*.

Connecting sequence may vary to some degree with job conditions and the individual; however, the method described below has proved successful and will be used when practicable.

Insure that wires remain twisted until time for connection. They may be separated back to the soldering clamp when one is used or to the fanning strip when no clamp is used. In either instance, pairs will remain twisted behind the fanning strip or up to the terminal board providing no fanning strip is being used.

Connect sufficient wires mechanically before starting to solder in order to minimize handling of tools and to permit the soldering iron to maintain a good working temperature.

Place all the conductors underneath (on the vertical blocks) or to the left (on horizontal blocks) of their associated rows of terminals and place the adjustable soldering clamp in position. Fold all wires back around the fanning strip, then pull them back into position and connect by rows.

On single notched terminals draw the wire up into the connecting notch until the insulation is up to, but not in, the notch. Bend the conductor around the end of the notch, flat across and against the back of the terminal. Continue bending the wire around the end of the terminal (opposite the notch) and break the wire off.

On terminals with two notches the procedure is the same as with a single notch terminal. The outer notch will be used unless a third wire is attached.

When making a solder connection, the following procedure is used:

(1) Wipe the tip of the iron on a wiping pad and then flow a small amount of solder on the tinned area.

(2) Place the tinned area of the tip on the connection (where the conductor and the terminal touch or the side opposite the insulated part of the conductor) and allow it to heat both the conductor and the terminal.

(3) When the terminal and conductor are sufficiently heated, tilt the tip of the iron and insert the end of the solder into the opening, between the iron and the terminal. Then press the tip down on the connection, melting the solder in the process.

(4) Rock the tip slightly as the solder begins to flow; this allows the solder to flow completely; then slide the tip of the iron from the terminal at the rear. Be careful to avoid moving of the wire and possibly causing a cold solder joint.

Wire wrap connections. Wrapped connection consists of a series of close wraps of wire. These wires are formed tightly, under tension, around a specifically designed terminal. The wraps may be soldered or remain unsoldered as specified or determined by requirements.

The wrapping tool bit is formed of metal containing an axial hole and a slot. The slot is on the outer surface of the bit and receives the skinned portion of the wire. The center hole (axial hole) accepts the terminal that the wire is to be terminated to. This basic tool can be powered by one of four ways: electrical, compressor air, mechanical, or hand.

The bit rotates while the sleeve remains fixed during operation. The two notches of the sleeve located on one end are for anchoring the insulated portion of the wire. This prevents any slipping of the wire during operation. On the same end of the bit is a U-shaped flare. This flare guides the wire into the slot of the bit. The wrapping tool is energized by operating the trigger and rotating the bit in the fixed sleeve.

On wire wrap terminals a minimum of 5 complete wraps are required, using 22 and 24 gauge wire. As a general rule, a $1^{1}/_{4}$- to $1^{1}/_{2}$-inch shiner (conductor stripped of insulation) provides enough shiner for a five wrap termination.

Once the insulation is removed from the conductor, the following procedure is used to secure a conductor by wire wrap:

(1) Insert the skinned portion of the wire into the slot; use the U-shaped flare on the sleeve as a guide for the wire. Insert the wire up to the insulation.

(2) Bend the insulated portion of the wire into the anchoring notch in the sleeve.

(3) Place the wire wrap tool (hand or gun) on the terminal up to the shoulder (wide part at the base of the terminal) of the terminal; or up to, but not over a previously connected wire.

(4) Operate the trigger, while keeping the tool straight or parallel with the terminal. Do not pull up on the tool or push against it; let the tool move up on the terminal by itself.

Exercises (223):

1. What is a fanned form?
2. What is the maximum number of terminal blocks a horizontal fanned form can fan out to?
3. What is the maximum that a vertical fanned form can fan out to?
4. What, concerning sewed forms, is predetermined before the forming operation begins?
5. What twine is used, if the maximum diameter of a sewed form is between $^{3}/_{8}$ to $1^{1}/_{2}$ inches in diameter?
6. What do you know about the diameter of a form sewed with a double strand of number 12 twine?
7. What does terminating consist of?
8. What two methods are used to secure conductors to terminals?
9. How far back on the terminal strip may conductors be untwisted when terminating?

10. What is the length, as a general rule, of the shiner when securing a conductor by wire wrap?

11. What is the minimum number of wraps for a wire wrap termination?

12. Where, on a notched terminal, is the wire broken off?

224. State how and when to connect power leads.

The power equipment is normally installed as a group, with each individual unit being mounted with its coordinating unit. Power panels are bolted to an angle-iron frame which gives them adequate support. The installed frame contains equipment which provides for supervision of all exchange equipment for controlling the operation of the storage battery and its charging equipment and for distribution of the direct current for operating the switching equipment and alternating current for ringing and tones. The Flotrol rectifier converts the incoming alternating current to direct current. This output DC changes the battery and provides operating current to the switching equipment.

All wiring to the interunit switching equipment is completed before any wires are connected to the battery or to the power equipment. Included in the power equipment wiring are the cables connecting the 48-volt DC supply with the central office switching equipment units, the cables for the power frame and battery, and the primary power cables from the 220-volt, 3-phase, 60 cycle AC. All cables are placed in their respective locations before terminations are to be made. All power cables terminate at the fuse panel of the power frame, but not all cables attach to fuse panels at the switching equipment frames. The cables are connected to busbars which have a specific polarity, which means that the conductors of the cable, likewise, are to be identified with a polarity—either negative (−) or positive (+). Observe good wiring and soldering practices at all times. Be sure that all connections are clean and tightened securely.

Formed cables may be supplied by the manufacturer to permit the installer to complete the cable connections rapidly and with greater assurance of a proper installation. The formed cables will be identified with a code number. The longer formed cables connect the power equipment to the equipment frames, and the shorter cables multiple the equipment frames.

Usually the positive (+) terminal of the storage battery, the ground potential ringing terminals on the power panel, and the ground bus bar (bunching board) of the distributing frame should be connected to ground. The preferred method for grounding each of the units is by providing each an individual attachment to the earth (ground). The simplest, yet most effective, ground for most conditions is a ground rod driven deeply into the soil. A cold water pipe may be used, but a common ground wire to this pipe for both the central office and electrical power protection panel is not permitted. A separate ground wire for each system must be used, and each wire is connected directly to a section of the pipe. This procedure reduces the possibility of hum or crossed-circuit effects.

The conduit and power circuit installation between the service entrance switch and the power equipment must conform to National Electrical Code requirements. The wiring, normally, is the very last to be installed before the system is put into operation. The central office ends of these conductors are attached before the ends at the service entrance switch are terminated. This procedure provides for greater safety while making the installation.

Exercises (224):

Answer the following questions about connecting power leads.

1. When power for the switching equipment bays connected?

2. Where do all power cables terminate?

3. What should you observe when terminating power cables?

4. What two items in the equipment bays are power cables attached to?

4-4. Plant-in-Place Records

Your first two questions are probably, what are plant-in-place drawings and what purpose do they serve?

Plant-in-place drawings or records show what, where, and how C-E equipment is installed; and they are essential for the maintenance and operation of these facilities. They are used for planning, modifications, expansions, and changes to C-E facilities. When you arrive at a new base, these drawings are invaluable as sources of information about your new exchange.

225. Given information about completed scheme actions, state how to correct and/or update plant-in-place records drawings.

Types of Records. There are five types of C-E plant-in-place records (PIPR). Each is explained in the following paragraphs.

Installation records. These are site adaptation records provided by Air Force Communications Service (AFCS); they show what equipment is installed, its location, and its interconnections. Included are drawings, narrative listings, catalog documents, and any other data such as tech orders, photographs, etc., that are necessary for future site planning, engineering, current accountability, operation, and maintenance.

Catalog documents. These are a part of the installations drawings; but are listed separately because of their importance to the PIPR system. The catalog documents include the drawing record index, engineering data lists, key sheets, and base layout drawings.

C-E schemes. These include installation narratives, materiel lists, test instructions, transitory drawings, standard drawings, and site adaptation drawings. Some of the drawings will become installation records when the scheme is implemented.

Interim records. Interim records are copies of scheme and installation records and associated AF Forms 1146 (Engineering Change Request/Authorization) marked by the installation team to show deviations from the planned installation; or marked by exchange personnel to show corrections.

These records are held and maintained as part of the PIPR to provide accurate installation records pending AFCS revision to the master drawing records.

Base C-E records. Base C-E records are maintenance, programming, engineering, and temporary installation records established and maintained by shop and base activities.

Maintenance records include line record cards, cable assignment records, and operational test reports.

Engineering and programming records include AF Forms 1261 (C-E Installation Completion and Commissioning Certificate), 1319 (Subsystem/System Test Verification and Commissioning Certificate), and 1325 (C-E Facility Removal Certificate); site concurrence letters (SCLs) and support requirements letter (SRLs); letters of agreement, real estate data, test results, program change documents, and other supporting and historical documents as directed by the major command.

Correcting and Updating PIPR Drawings. Whether you are part of an Engineering Installation (EI) team or a member of a maintenance shop you need to know how to read these drawings and make corrections when you find errors or a change is made that requires updating the drawings.

Regardless of the reason for changing drawings a system that everyone understands is necessary; that is, if your records are to be correct when the new drawings are returned to you.

A simple system using three colors is used Air Force wide to make changes to the drawings.

Yellow. The color yellow is used to identify deleted data, notes, and equipment shown on a drawing. In other words, if a selector bay is removed from your exchange you trace over that equipment, on the floor plan drawing, with a yellow pencil to indicate the equipment has been removed.

Red. The color red is used to indicate additions to the facility.

Blue. This color is used for notes to instruct the draftsman, engineers, and others.

At least two sets of drawings are annotated to reflect changes in the facility. One set is sent forward, for the purpose of correcting the master drawings and getting updated drawings made; the other set is maintained in the organization as the installation drawing until updated copies are received.

Exercises (225):

1. A bay of dial-to-dial trunks has been added to your exchange. What do you do to the floor plan drawing?

2. What color pencil should be used for each of the following command directed changes to the selector equipment in your exchange?
   a. C-1 is changed from .01 mf capacitor to .025 mf.
   b. The lead from contact 3 of relay B to contact 4 of relay C is removed.
   c. A lead from contact 4 of the VONs to contact 10 of relay C is added.

3. How many copies of affected drawings are marked up to reflect changes and what happens to the copies?

CHAPTER 5

Central Office Records

RECORDS, THE MERE term is enough to strike terror in the hearts of even the best repairmen. Let's face it, records are a pain; however, an even bigger pain is records that are messy, incomplete, or incorrect. Without records that are legible, complete, and correct, it is absolutely impossible to test the cable pair for a specific circuit or telephone number.

Records are vital in any reasonably well-run central office. There is nothing particularly difficult about properly maintaining your records. Simple everyday keeping up with them will insure that you have records which you can rely on.

5-1. AFTO Forms

In this chapter we discuss the telephone number assignment record, line record card, circuit layout record/trouble report, cable records, and cable transfer worksheet and explain how they relate to the local communications service order. We will also touch on the storage battery recora.

226. Given information extracted from AF Forms 1075, make appropriate entries on a telephone number assignment record, interpret selected entries, and identify all errors.

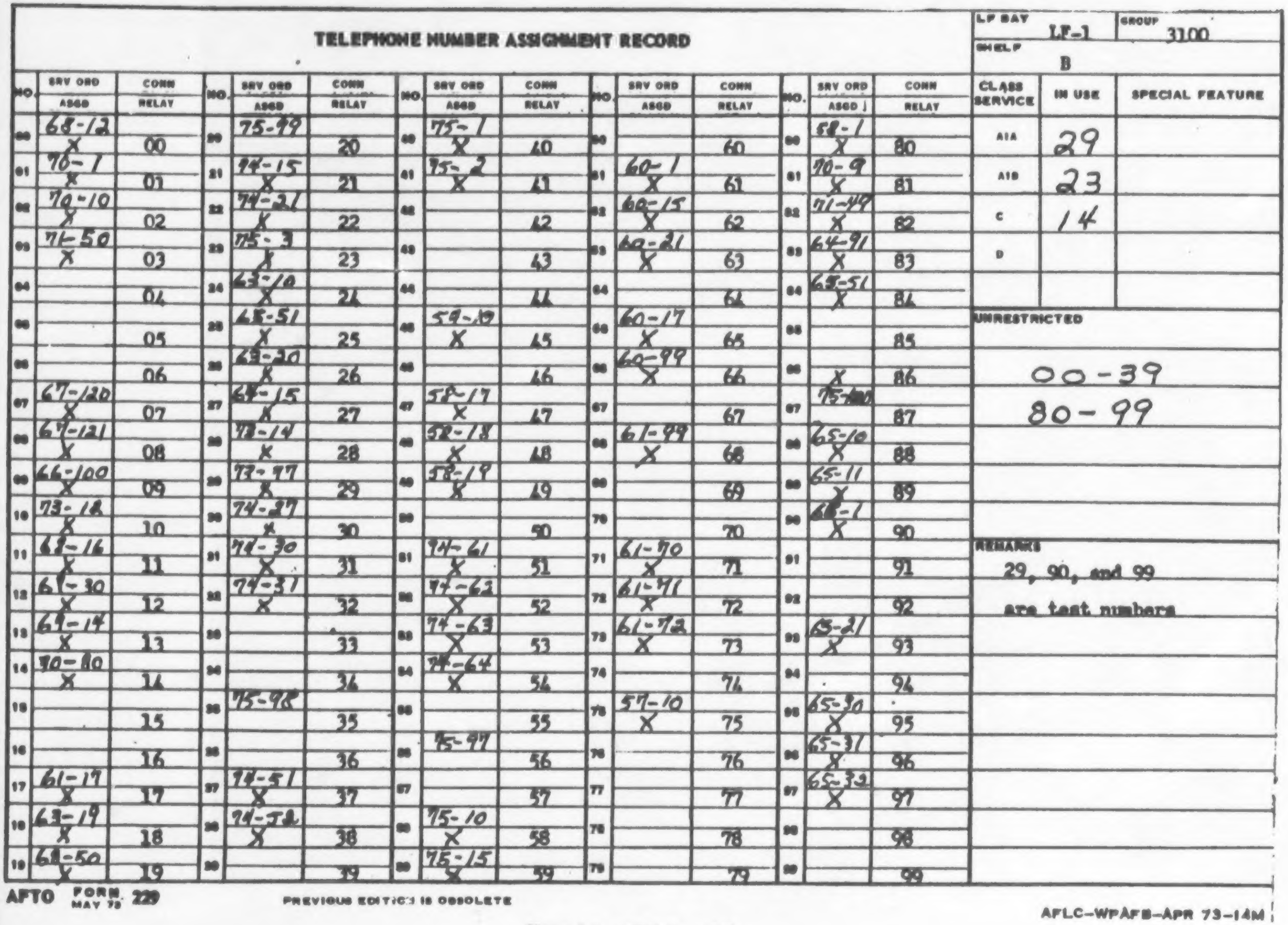
Telephone Number Assignment Record, AFTO Form 229. Figure 5-1 pictures the AFTO 229. The purpose of the form is to record the assignment of telephone numbers.

In figure 5-1, notice the numbers on the form from 00 to 99. These numbers are the last two digits of a telephone number. For instance, these particular numbers are in linefinder/connector group 3100 (see "3100" in the LF Bay block at top right of form). Since this is the case, the first number, 00, would be telephone number 3100 and the last number, 99, would be telephone number 3199. Notice the X marks in the Asgd (assigned) column beside the various telephone numbers. The X indicates that a particular telephone number has been assigned and is in service. You mark an X by a telephone number on the assignment record only when an installation has been completed. For example, refer to telephone number 3187 (number 87) on the assignment form. Notice the number 75-100, that appears beside it. This number is the service order number that appeared on the communications service order (see fig. 5-2). Why does the number 75-100 appear by telephone number 3187? We refer to figure 5-2 to explain why. The telephone number, 3187, was used for the new main line installed in the day room of the 3760th Instructor Squadron. When the inside plant repairman selected the number he did not select the number at random. Instead, he checked the telephone number assignment record to determine the number to use. Since 3187 wasn't in use, he placed the service order number 75-100 beside 3187 until the installation was completed and then placed an X beside it in the Asgd column. One reason why a service order number is written in the assigned column beside a selected telephone number before an installation is completed is to show that the number will be used for the pending installation.

Continuing our discussion of the telephone number assignment record, the top right part of the form indicates the linefinder bay and group that the numbers 00-99 are located in. Directly under this information is the linefinder shelf these numbers are located in. Below the shelf information, you see a block containing the class of service, how many in use, and special features. The classes of service for assigned telephone numbers are:

AXA—Unrestricted.
B—Unrestricted—paid for by subscriber.
C—Restricted for official on base calls.
D—Special numbers assigned for fire reporting, guard phones, etc.

The Unrestricted block of the AFTO Form 229 (see fig. 5-1) shows the total unrestricted numbers in use. As you can see, 00-39 and 80-99 are either class A1A or class A1B numbers. As you add or delete new telephone numbers, you will have to make adjustment in this block to reflect the action you have taken.



TELEPHONE NUMBER ASSIGNMENT RECORD

LF BAY: LF-1
GROUP: 3100
SHELF: B

NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY
00	68-12 X	00	20	75-99	20	40	75-1 X	40	60		60	80	58-1 X	80
01	70-1 X	01	21	74-15 X	21	41	75-2 X	41	61	60-1 X	61	81	70-9 X	81
02	70-10 X	02	22	74-21 X	22	42		42	62	60-15 X	62	82	71-49 X	82
03	71-50 X	03	23	75-3 X	23	43		43	63	60-21 X	63	83	64-91 X	83
04		04	24	63-10 X	24	44		44	64		64	84	65-51 X	84
05		05	25	68-51 X	25	45	59-10 X	45	65	60-17 X	65	85		85
06		06	26	63-20 X	26	46		46	66	60-99 X	66	86	X	86
07	67-120 X	07	27	69-15 X	27	47	58-17 X	47	67		67	87	75-100	87
08	67-121 X	08	28	73-14 X	28	48	58-18 X	48	68	61-99 X	68	88	65-10 X	88
09	66-100 X	09	29	73-97 X	29	49	58-19 X	49	69		69	89	65-11 X	89
10	73-18 X	10	30	74-27 X	30	50		50	70		70	90	65-1 X	90
11	68-16 X	11	31	74-30 X	31	51	74-61 X	51	71	61-70 X	71	91		91
12	61-30 X	12	32	74-37 X	32	52	74-62 X	52	72	61-71 X	72	92		92
13	69-14 X	13	33		33	53	74-63 X	53	73	61-72 X	73	93	65-21 X	93
14	70-80 X	14	34		34	54	74-64 X	54	74		74	94		94
15		15	35	75-98	35	55		55	75	57-10 X	75	95	65-30 X	95
16		16	36		36	56	75-97	56	76		76	96	65-31 X	96
17	61-17 X	17	37	74-51 X	37	57		57	77		77	97	65-32 X	97
18	63-19 X	18	38	74-52 X	38	58	75-10 X	58	78		78	98		98
19	68-50 X	19	39		39	59	75-15 X	59	79		79	99		99

CLASS SERVICE	IN USE	SPECIAL FEATURE
A1A	29	
A1B	23	
C	14	
D		

UNRESTRICTED

00-39
80-99

REMARKS

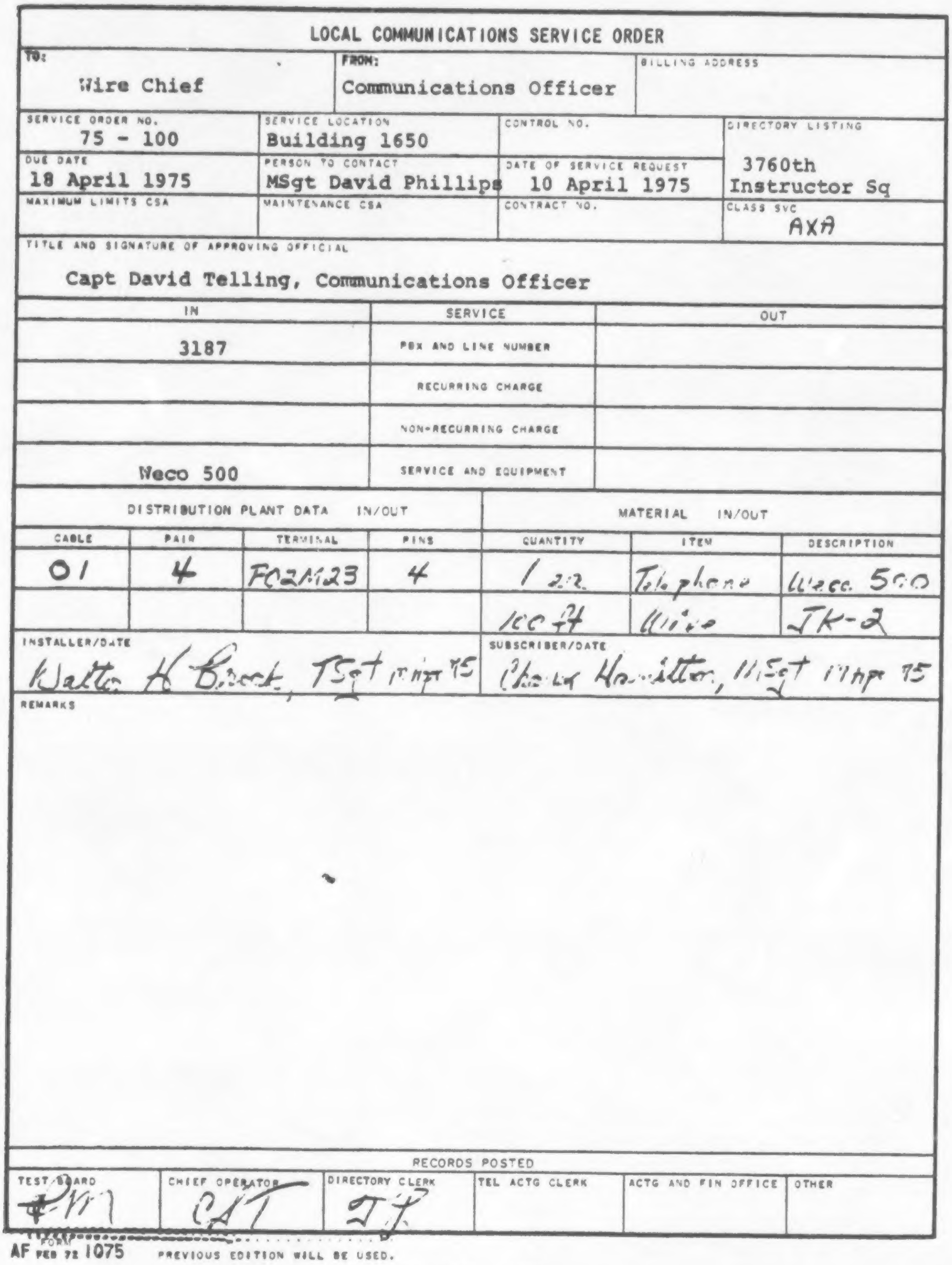
29, 90, and 99 are test numbers

AFTO FORM MAY 73 229

PREVIOUS EDITION IS OBSOLETE

AFLC-WPAFB-APR 73-14M

Figure 5-1. AFTO Form 229.



LOCAL COMMUNICATIONS SERVICE ORDER

TO: Wire Chief	FROM: Communications Officer	BILLING ADDRESS	
SERVICE ORDER NO. 75 - 100	SERVICE LOCATION Building 1650	CONTROL NO.	DIRECTORY LISTING 3760th Instructor Sq
DUE DATE 18 April 1975	PERSON TO CONTACT MSgt David Phillips	DATE OF SERVICE REQUEST 10 April 1975	
MAXIMUM LIMITS CSA	MAINTENANCE CSA	CONTRACT NO.	CLASS SVC AXA

TITLE AND SIGNATURE OF APPROVING OFFICIAL

Capt David Telling, Communications Officer

IN	SERVICE	OUT
3187	PBX AND LINE NUMBER	
	RECURRING CHARGE	
	NON-RECURRING CHARGE	
Weco 500	SERVICE AND EQUIPMENT	

DISTRIBUTION PLANT DATA IN/OUT				MATERIAL IN/OUT		
CABLE	PAIR	TERMINAL	PINS	QUANTITY	ITEM	DESCRIPTION
01	4	FC2M23	4	1 ea.	Telephone	Weco 500
				100 ft	Wire	JK-2

INSTALLER/DATE
Walter H Brock, TSgt 17 Apr 75

SUBSCRIBER/DATE
Charles Hamilton, MSgt 17 Apr 75

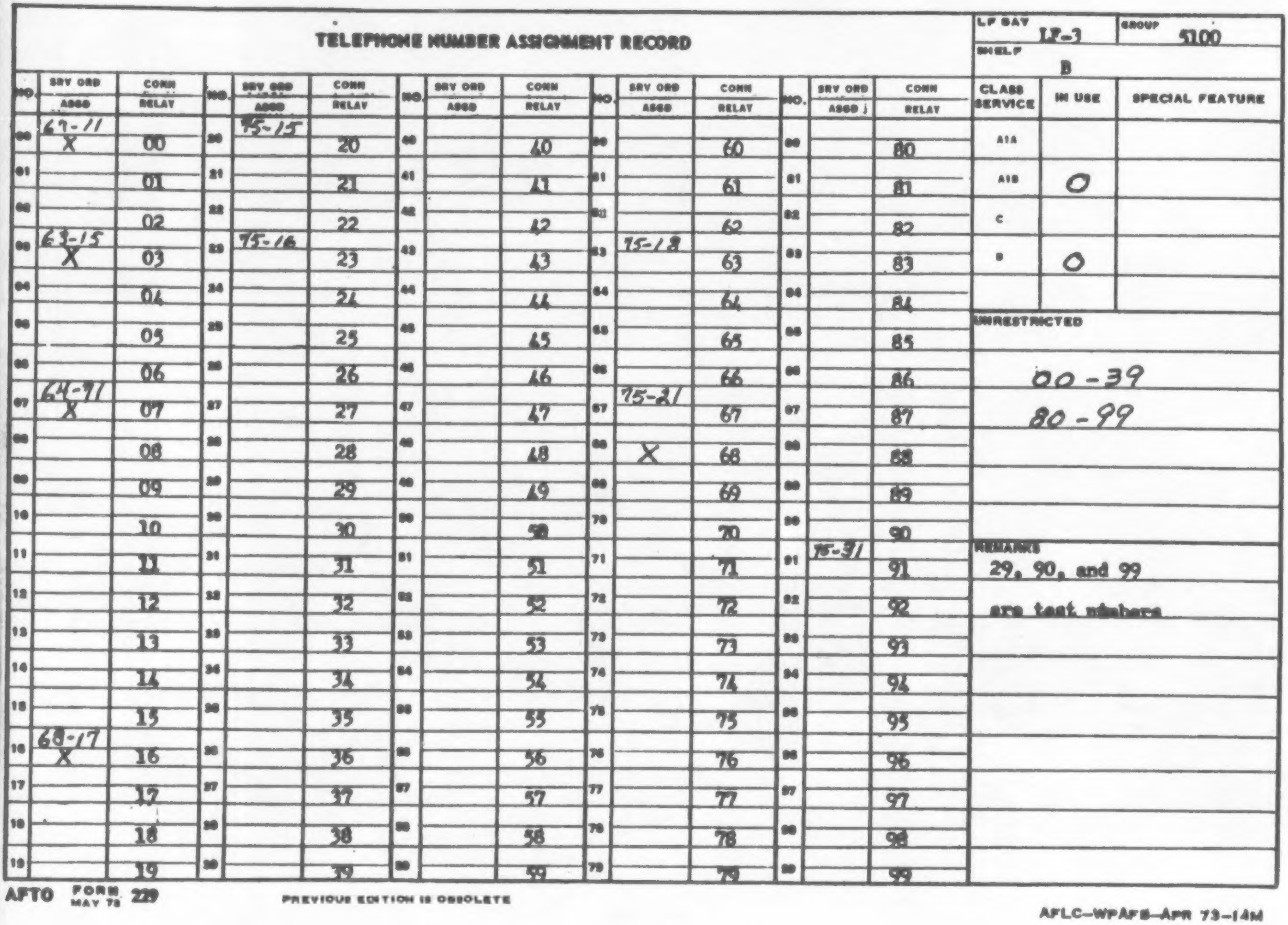
REMARKS

RECORDS POSTED

TEST BOARD	CHIEF OPERATOR	DIRECTORY CLERK	TEL ACTG CLERK	ACTG AND FIN OFFICE	OTHER
PM	CAT	DF			

AF FORM FEB 72 1075 PREVIOUS EDITION WILL BE USED.

Figure 5-2. AF Form 1075.



TELEPHONE NUMBER ASSIGNMENT RECORD

LF BAY: LF-3
GROUP: 5100
SHELF: B

NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY
00	67-11 X	00	20	75-15	20	40		40	60		60	80		80
01		01	21		21	41		41	61		61	81		81
02		02	22		22	42		42	62		62	82		82
03	63-15 X	03	23	75-16	23	43		43	63	75-18	63	83		83
04		04	24		24	44		44	64		64	84		84
05		05	25		25	45		45	65		65	85		85
06		06	26		26	46		46	66		66	86		86
07	64-91 X	07	27		27	47		47	67	75-21	67	87		87
08		08	28		28	48		48	68	X	68	88		88
09		09	29		29	49		49	69		69	89		89
10		10	30		30	50		50	70		70	90		90
11		11	31		31	51		51	71		71	91	75-31	91
12		12	32		32	52		52	72		72	92		92
13		13	33		33	53		53	73		73	93		93
14		14	34		34	54		54	74		74	94		94
15		15	35		35	55		55	75		75	95		95
16	68-17 X	16	36		36	56		56	76		76	96		96
17		17	37		37	57		57	77		77	97		97
18		18	38		38	58		58	78		78	98		98
19		19	39		39	59		59	79		79	99		99

CLASS SERVICE	IN USE	SPECIAL FEATURE
A1A		
A1B	0	
C		
D	0	

UNRESTRICTED

00-39
80-99

REMARKS

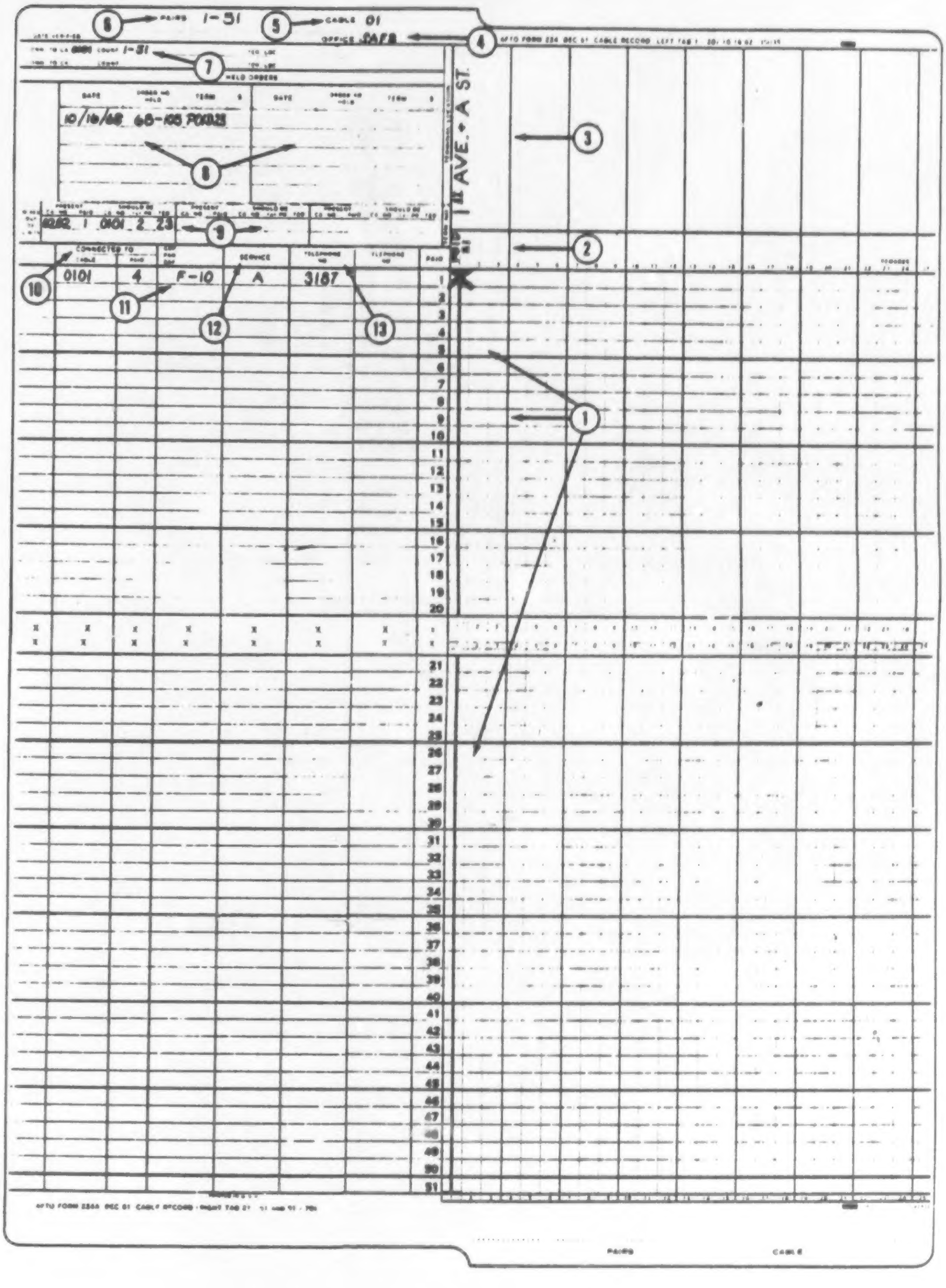
29, 90, and 99
are test numbers

AFTO FORM MAY 73 229 PREVIOUS EDITION IS OBSOLETE

AFLC—WPAFB—APR 73—14M

Figure 5-3. AFTO Form 229 (objective 226, exercise 1).

182



PAIRS 1-51

CABLE 01

OFFICE SAFB

AFTO FORM 224 DEC 61 CABLE RECORD LEFT TAB

COUNT 1-51

HELD ORDERS

DATE	ORDER NO HELD	TERM
10/16/68	68-105 P0(1)25	

1st AVE. + A ST.

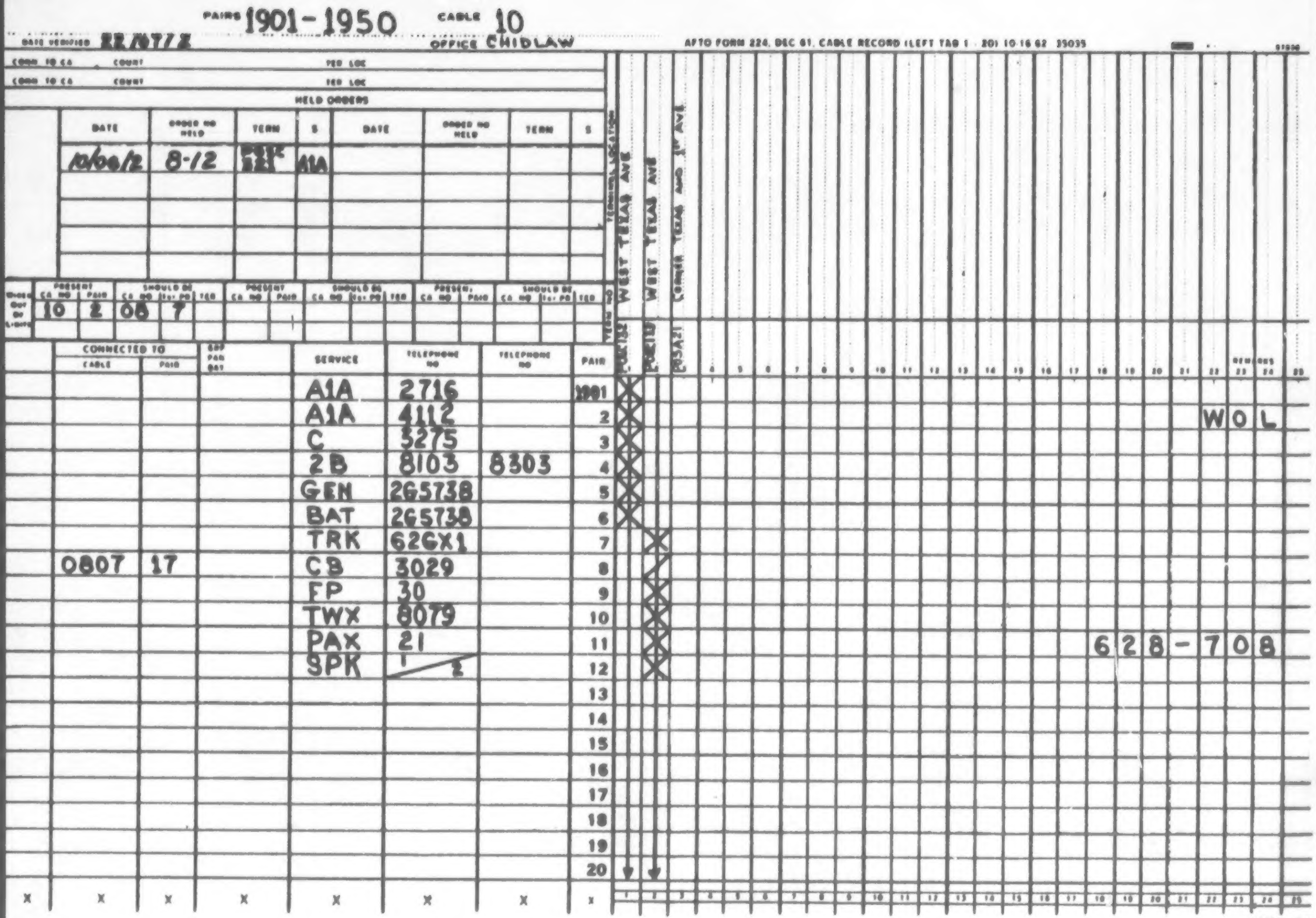
CONNECTED TO CABLE	PAIR		SERVICE	TELEPHONE NO	PAIR
0101	4	F-10	A	3187	1

PAIRS

CABLE

①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
⑫
⑬

Figure 5-4. AFTO Form 224 series.



PAIRS 1901-1950 CABLE 10

DATE VERIFIED 22/07/72 OFFICE CHIDLAW

AFTO FORM 224, DEC 61, CABLE RECORD (LEFT TAB 1 - 20) 10-16-62 35035

CONN TO CA COUNT TER LOC

CONN TO CA COUNT TER LOC

HELD ORDERS

DATE	ORDER NO HELD	TERM	S	DATE	ORDER NO HELD	TERM	S
10/06/2	8-12	[illegible]	A1A				

	PRESENT CA NO	PRESENT PAIR	SHOULD BE CA NO	SHOULD BE PAIR	TER
	10	2	08	7	

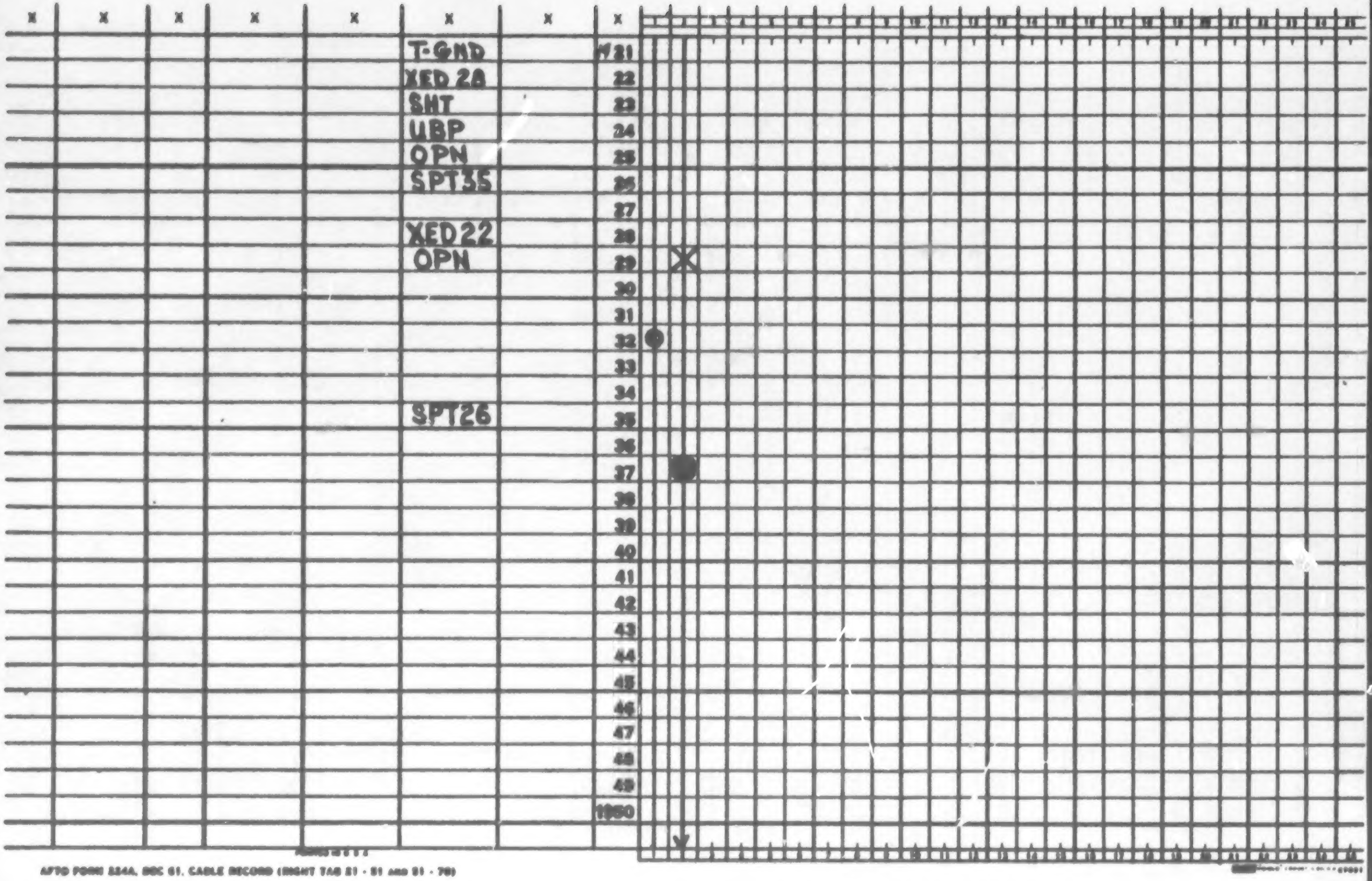
TERMINAL LOCATION: 1 WEST TEXAS AVE; 2 WEST TEXAS AVE; 3 CORNER TEXAS AND 1st AVE

TERM NO: 1 [illegible]; 2 [illegible]; 3 [illegible]

CONNECTED TO CABLE	CONNECTED TO PAIR	SERVICE	TELEPHONE NO	TELEPHONE NO	PAIR	REMARKS
		A1A	2716		1901	
		A1A	4112		2	WOL
		C	3275		3	
		2B	8103	8303	4	
		GEN	265738		5	
		BAT	265738		6	
		TRK	626X1		7	
0807	17	CB	3029		8	
		FP	30		9	
		TWX	8079		10	
		PAX	21		11	628-708
		SPK	1 / 2		12	
					13	
					14	
					15	
					16	
					17	
					18	
					19	
					20	

BEA—224

Figure 5-5. AFTO Form 224 (objective 227, exercise 1).



x	x	x	x	x	x	x	x
					T-GND		1921
					XED 28		22
					SHT		23
					UBP		24
					OPN		25
					SPT35		26
							27
					XED22		28
					OPN		29
							30
							31
							32
							33
							34
					SPT26		35
							36
							37
							38
							39
							40
							41
							42
							43
							44
							45
							46
							47
							48
							49
							1950

AFTO FORM 224A, DEC 61, CABLE RECORD (RIGHT TAB 21 - 51 AND 51 - 70)

PAIRS 1901 — 1950 CABLE 10 BEA—224A

Figure 5-6. AFTO Form 224A (objective 227, exercise 1).

The last block of the AFTO Form 229 is the Remarks column. It is used for any significant information you desire to write in. However, in most cases, test numbers, such as the ones shown, are written in this column.

Exercise (226):

1. Use the information shown below to annotate figure 5-3.
   a. Work order 75-15 installed on 10 April 1975.
   b. Work orders 75-18 and 75-21 were completed on 15 April 1975.
   c. Circle the error in the form.
   d. Phone number 5119 is assigned to work order 75-57.
   e. Complete the IN USE column.

227. Given information extracted from AF Forms 1075, make appropriate entries on telephone cable records.

Cable Record, AFTO Form 224 Series. The cable record is one of the most important central office records you are required to maintain. The reason is because the record contains information showing the termination of all telephones in your system. Figure 5-4 pictures a portion of the cable record series—the AFTO Forms 224 and 224A. The AFTO Form 224 is called a left tab and can accommodate from 1 to 20 pairs. The AFTO Form 224A is called a right tab and can accommodate 31 pairs, making a total of 51 pairs that the AFTO Forms 224 and 224A can accomodate.

Before we get into a detailed explanation of the cable record, AFTO Form 224 series, let's see the relationship of these records with the communications service order. Referring to the communications service order in figure 5-2 for a moment, notice the distribution plant data block. The information such as the cable, pair, terminal, and pin count needed to install a new main line is obtained from the cable record, which is made up to show all the distribution plant data. This data is obtained from cable layout maps drawn up after completion of the outside plant cable scheme at your base.

When it becomes necessary to install a new telephone main line, you will have to refer to the cable record to obtain the necessary distribution plant data for the installation. This data will then be written on the local communications service order, as shown in figure 5-2. You also make appropriate entries pertaining to the installation on the cable record.

Referring to figure 5-4 again, let us examine the entries that appear on the cable record, AFTO Form 224 series. You notice boxed numbers on the cable record with arrows pointed to the portions of the form we wish to explain. To understand our explanation of the form thoroughly, relate the boxed numbers on the form with the following:

(1) Terminal count distribution—this entry is a permanent, solid line drawn in beside pairs 1 through 51 which reflects the pair count of a specific terminal. When a main line or special circuit is installed, you place an X to indicate which pair connects the circuit.

(2) Pole and terminal number—this entry shows the pole and terminal number for pair 1 count through 51.

(3) Pole and terminal location—this entry is the exact location (area) where a pole and terminal are located.

(4) Office—the name or number of the telephone central office is entered here.

(5) Cable—the number of the cable is shown here.

(6) Pair count—this entry is the pair count of the cable.

(7) Connected to cable information—entries are made here where one cable connects to another cable. One reason for connecting cables is to provide added flexibility for cable distribution.

(8) Held orders—service order entries are made here when the installation cannot be performed as scheduled.

(9) Wired out of limits—entries are made here when, due to congested facilities, a subscriber is being served from a cable and terminal other than the one closest to his premises.

(10) Cable connection information—this entry reflects that a specific pair in one cable is connected to a specific pair of another cable to reach the premises of a subscriber.

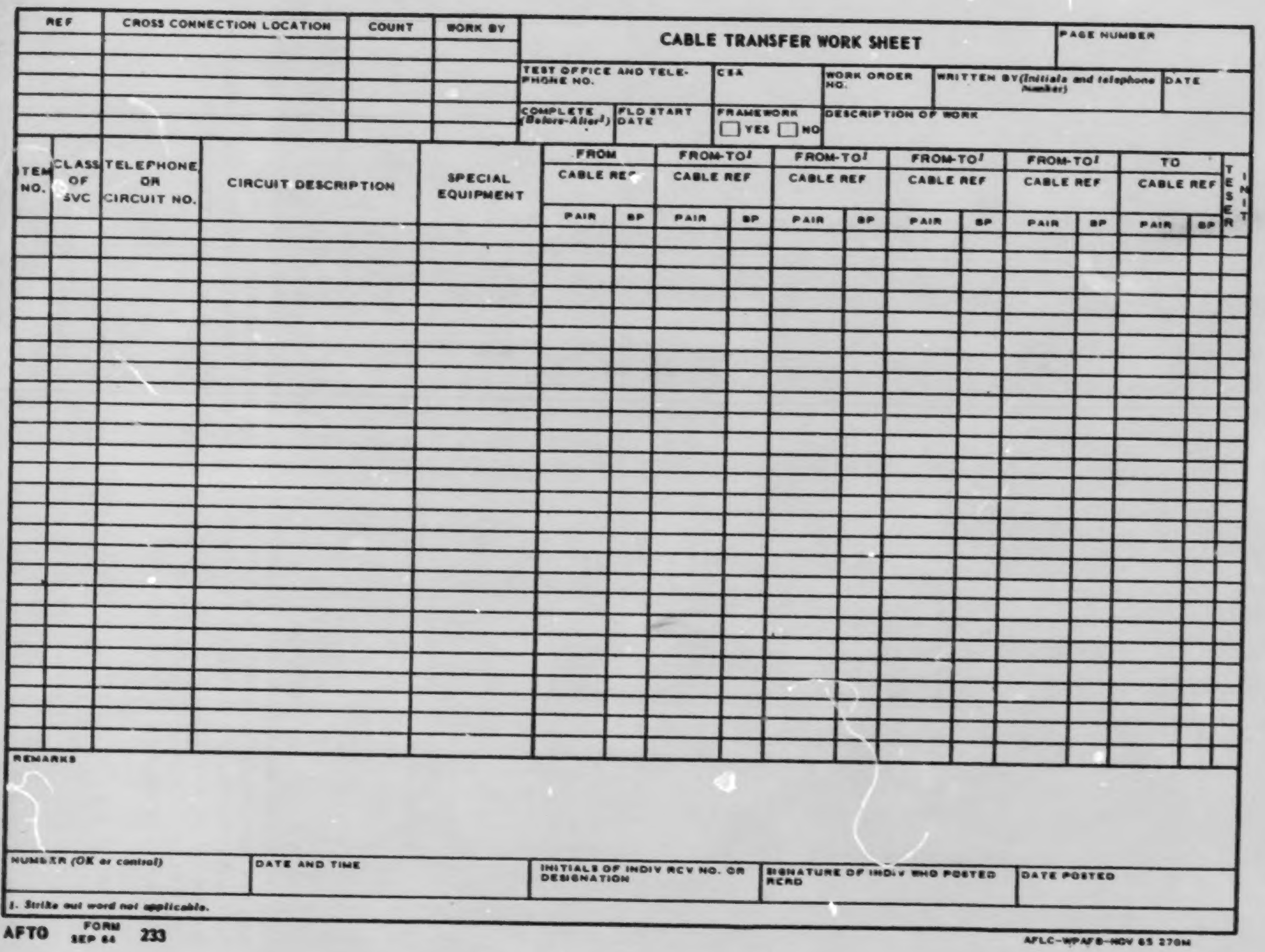
(11) Grp-pan-bay—an entry is made here where a circuit is routed through fuses or through jack or panel appearances at an attendant's cabinet. The entry is usually the fuse or jack number.

(12) Service—the space is reserved to enter services such as class A, B, or C telephones and special circuit entries.

(13) Telephone number—the number of the subscriber's telephone is entered here.

Exercise (227):

1. Annotate the cable records, figures 5-5 and 5-6, using the information given below.
   a. Circuit XN1G, a teletype (TWX) circuit, was installed on pair 1920 of cable 10 at terminal POIC139.
   b. The cable crew installed a 20 pair leg of cable 10, from pair 1931 through 1950, at the corner of Texas and 1st Avenue.



REF	CROSS CONNECTION LOCATION	COUNT	WORK BY

CABLE TRANSFER WORK SHEET

PAGE NUMBER

TEST OFFICE AND TELEPHONE NO.

CSA

WORK ORDER NO.

WRITTEN BY *(Initials and telephone number)*

DATE

COMPLETE *(Before-After[1])*

FLD START DATE

FRAMEWORK ☐ YES ☐ NO

DESCRIPTION OF WORK

ITEM NO.	CLASS OF SVC	TELEPHONE OR CIRCUIT NO.	CIRCUIT DESCRIPTION	SPECIAL EQUIPMENT	FROM		FROM-TO[1]		FROM-TO[1]		FROM-TO[1]		FROM-TO[1]		TO		TESTER	INIT
					CABLE REF		CABLE REF		CABLE REF		CABLE REF		CABLE REF		CABLE REF			
					PAIR	BP	PAIR	BP	PAIR	BP	PAIR	BP	PAIR	BP	PAIR	BP		

REMARKS

NUMBER (OK or control)

DATE AND TIME

INITIALS OF INDIV RCV NO. OR DESIGNATION

SIGNATURE OF INDIV WHO POSTED RCRD

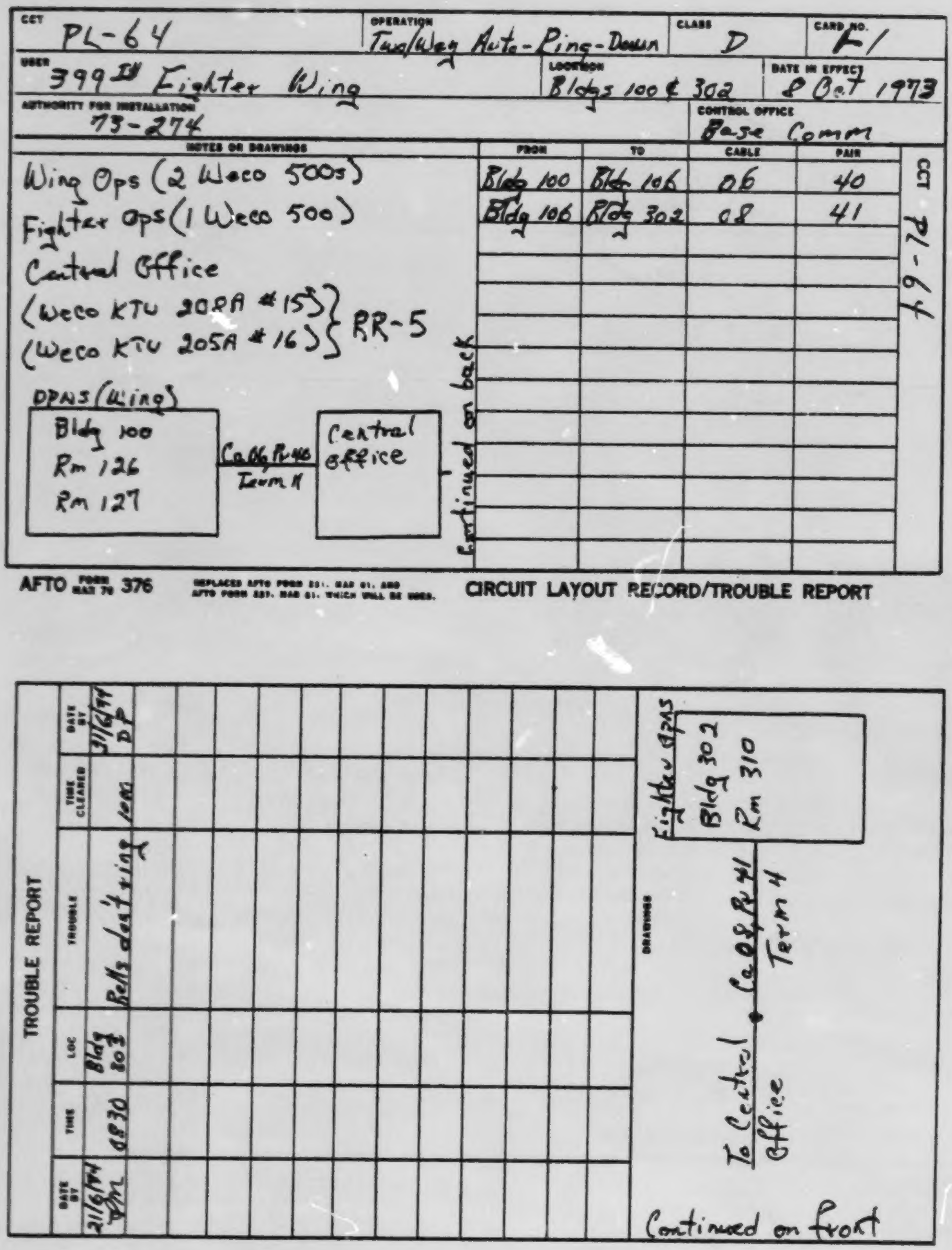
DATE POSTED

1. *Strike out word not applicable.*

AFTO FORM SEP 64 233

AFLC-WPAFB-NOV 65 270M

Figure 5-7. AFTO Form 233.



CCT PL-64

OPERATION Two/Way Auto-Ring-Down

CLASS D

CARD NO. F1

USER 399th Fighter Wing

LOCATION Bldgs 100 & 302

DATE IN EFFECT 8 Oct 1973

AUTHORITY FOR INSTALLATION 73-274

CONTROL OFFICE Base Comm

NOTES OR DRAWINGS

Wing Ops (2 Weco 500s)
Fighter Ops (1 Weco 500)
Central Office
(Weco KTU 202A #15) } RR-5
(Weco KTU 205A #16) }

OPNS (Wing)

Bldg 100
Rm 126
Rm 127

Ca 06 Pr 40
Term K

Central Office

Continued on back

FROM	TO	CABLE	PAIR
Bldg 100	Bldg 106	06	40
Bldg 106	Bldg 302	08	41

CCT PL-64

AFTO FORM MAR 70 **376** REPLACES AFTO FORM 331, MAR 61, AND AFTO FORM 337, MAR 61, WHICH WILL BE USED.

CIRCUIT LAYOUT RECORD/TROUBLE REPORT

TROUBLE REPORT

DATE BY	TIME	LOC	TROUBLE	TIME CLEARED	DATE BY
21/6/74 Pm	0830	Bldg 302	Bells don't ring	1000	31/6/74 DP

DRAWINGS

Fighter Opns

Bldg 302
Rm 310

Ca 08 Pr 41
Term 4

To Central Office

Continued on front

Figure 5-8. AFTO Form 376.

c. Telephone 4175, Class A1, was installed on pair 1944 of cable 10 on terminal PO5A21, but is wired out of limits.

228. Given information extracted from AF Forms 1075 and appropriate cable records, prepare a cable tranfer worksheet.

Cable Transfer Worksheet, AFTO Form 233. The cable transfer worksheet is used to record information about cable and terminal transfer work. For instance, a big office, department, directorate, or organization moves from one building on base to another and wants the communications services and phone numbers to remain the same. Without some means of keeping this information organized, you would really have problems.

In the first major block of the form, top left-hand corner of figure 5-7, you find four columns. In the REF column enter the cable number(s) of the cable(s) being used. In the CROSS CONNECTION LOCATION column enter the location of each cross-connect point, in sequence. In the count column, enter the numbers of the first and last cable pairs of each cable listed in the REF column. In the WORK BY column record the initials of the person doing the work at the corresponding cross-connect point.

In the upper right-hand corner of the form is a PAGE NUMBER block, this is used if more than one page is used. A two-part number, the first indicating the page number and the second indicating the total number of pages, should be used.

In the TEST OFFICE AND TELEPHONE NO. block list the name and telephone number of the control office that is to perform the testing. The number of the work order authorizing the move is entered in the WORK ORDER NO. block. The initials on the person making up the worksheet and their phone number are entered in the WRITTEN BY block.

In the COMPLETE (BEFORE-AFTER) block, cross out either the BEFORE or AFTER and enter the appropriate date. Enter the start date of the job in the FLD START DATE block. In the FRAMEWORK block enter Yes or No as appropriate. In the DESCRIPTION OF WORK enter a brief description of the work being done. Enter the numbers indicating the numerical sequence of the work being done in the ITEM No. column. The next four columns, CLASS OF SVC, TELEPHONE OR CIRCUIT NO., CIRCUIT DESCRIPTION, and SPECIAL EQUIPMENT columns are self-explanatory. The information for these columns is obtained from the AFTO Forms 121 and 376 of the telephone and circuit numbers being transferred.

There are four FROM-TO/CABLE REF columns, side-by-side, and a TO/CABLE REF column. Each major column contains a PAIR and BP column. Cross out the word FROM or TO which is not applicable; in the CABLE REF column enter the proper cable reference number; in the PAIR column enter the cable pair number; and in the BP column enter the binding post number if applicable. In the TESTER INIT column enter the initials of the person performing the test on the corresponding circuit.

In the four blocks at the bottom of the form enter the signature of the person who accomplished the work, the date and time the work was completed, the signature of the person posting the applicable central office records, and the date they are posted.

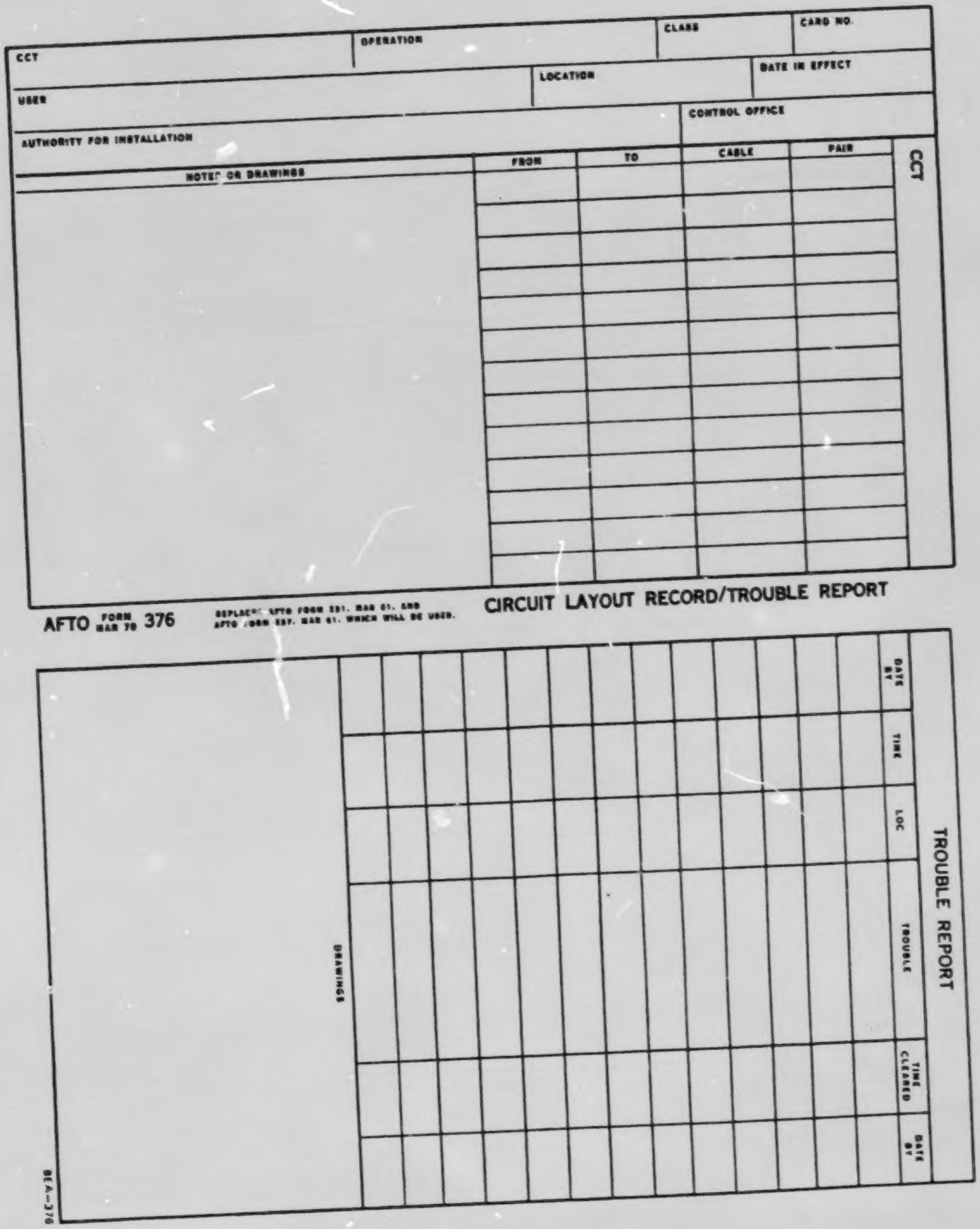
Exercise (228):

1. Use the following information to complete the appropriate blocks of AFTO Form 233, figure 5-7.

The circuits of cable 10, pairs 1907 (see fig. 5-5) through 1912, are being tranferred to cable 08 pairs 4 through 9 in terminal PO1F25. The work order authorizing the move is 75-182. The test office is the central office, telephone number 2224. The job must be completed before 10 May 1975 and should start on 8 May 1975.

229. Given information extracted from AF Forms 1075, make entries on AFTO Form 376 and state what other AFTO forms will be affected by the entries.

Circuit Layout Record/Trouble Report AFTO Form 376. Figure 5-8 pictures the circuit layout record/trouble report. The entries on this form are similiar to the AFTO Form 121 except that this form has information written on it pertinent to special circuits such as teletype, radio, or private lines which are routed over the base telephone cable system. In reference to figure 5-8, notice that the circuit layout card pertains to a two-way automatic ringdown circuit. The form indicates that the automatic ringdown circuit, as determined by local procedures, is PL 64 (private line 64). The class of service for this circuit, as you can see, is class D which is the class of service assigned special circuits. Notice the block labeled Card No. in the extreme top right of the record. See the number 1-1 written in? When a particular circuit requires more than one circuit layout record, the records should be numbered in numerical sequence such as 1-1, 1-2, 1-3, etc.



CCT
OPERATION
CLASS
CARD NO.
USER
LOCATION
DATE IN EFFECT
AUTHORITY FOR INSTALLATION
CONTROL OFFICE

NOTES OR DRAWINGS	FROM	TO	CABLE	PAIR	CCT

AFTO FORM MAR 70 376 REPLACES AFTO FORM 331, MAR 61, AND AFTO FORM 337, MAR 61, WHICH WILL BE USED.

CIRCUIT LAYOUT RECORD/TROUBLE REPORT

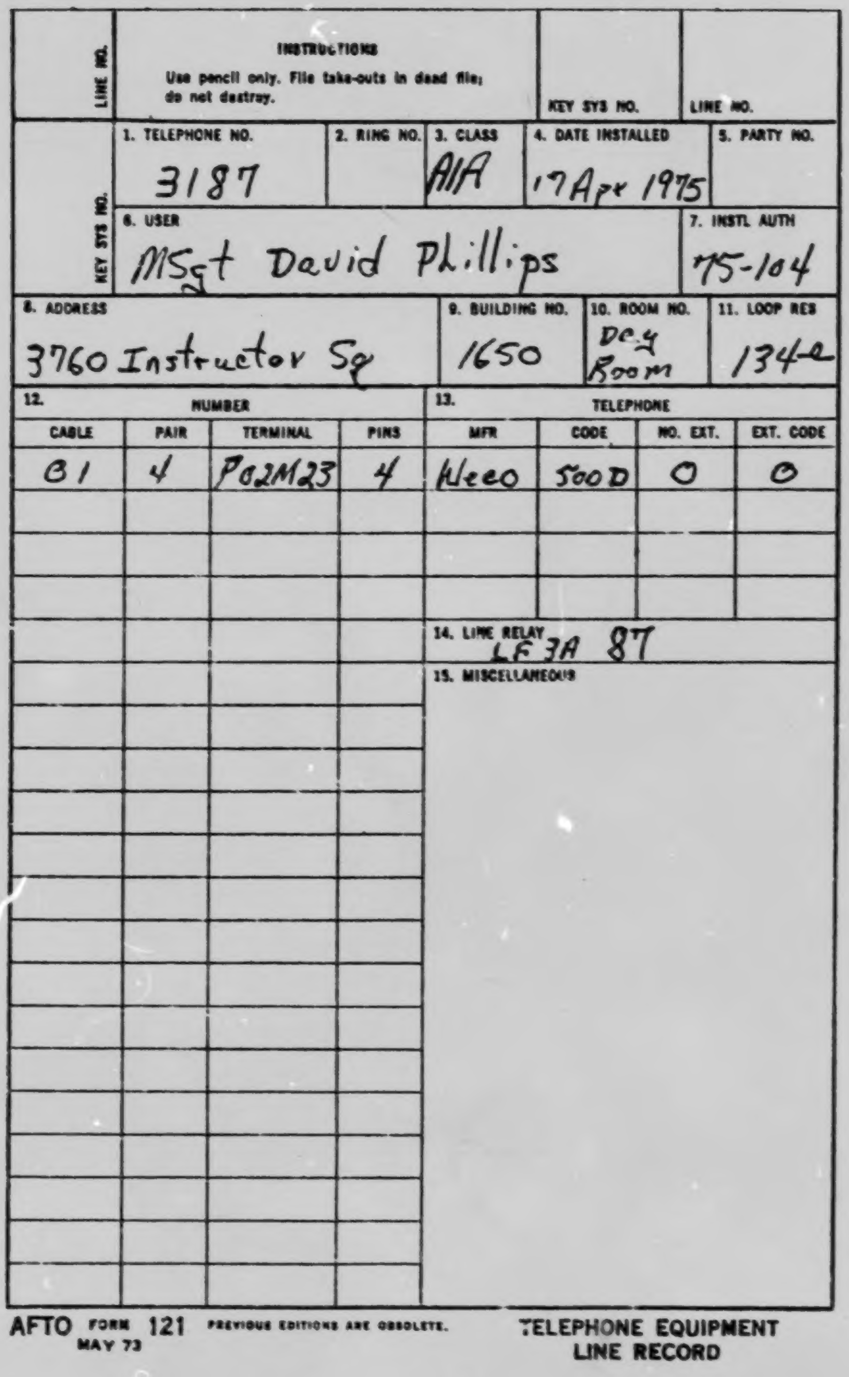
TROUBLE REPORT

DATE BY	TIME	LOC	TROUBLE	TIME CLEARED	DATE BY

DRAWINGS

SEA-376

Figure 5-9. AFTO Form 376 (objective 229, exercise 1).



LINE NO.

INSTRUCTIONS

Use pencil only. File take-outs in dead file; do not destroy.

KEY SYS NO.

LINE NO.

KEY SYS NO.

1. TELEPHONE NO. 3187
2. RING NO.
3. CLASS A1A
4. DATE INSTALLED 17 Apr 1975
5. PARTY NO.
6. USER MSgt David Phillips
7. INSTL AUTH 75-104
8. ADDRESS 3760 Instructor Sq
9. BUILDING NO. 1650
10. ROOM NO. Day Room
11. LOOP RES 134Ω

12.	NUMBER			13.	TELEPHONE		
CABLE	PAIR	TERMINAL	PINS	MFR	CODE	NO. EXT.	EXT. CODE
01	4	P02M23	4	Weco	500D	0	0

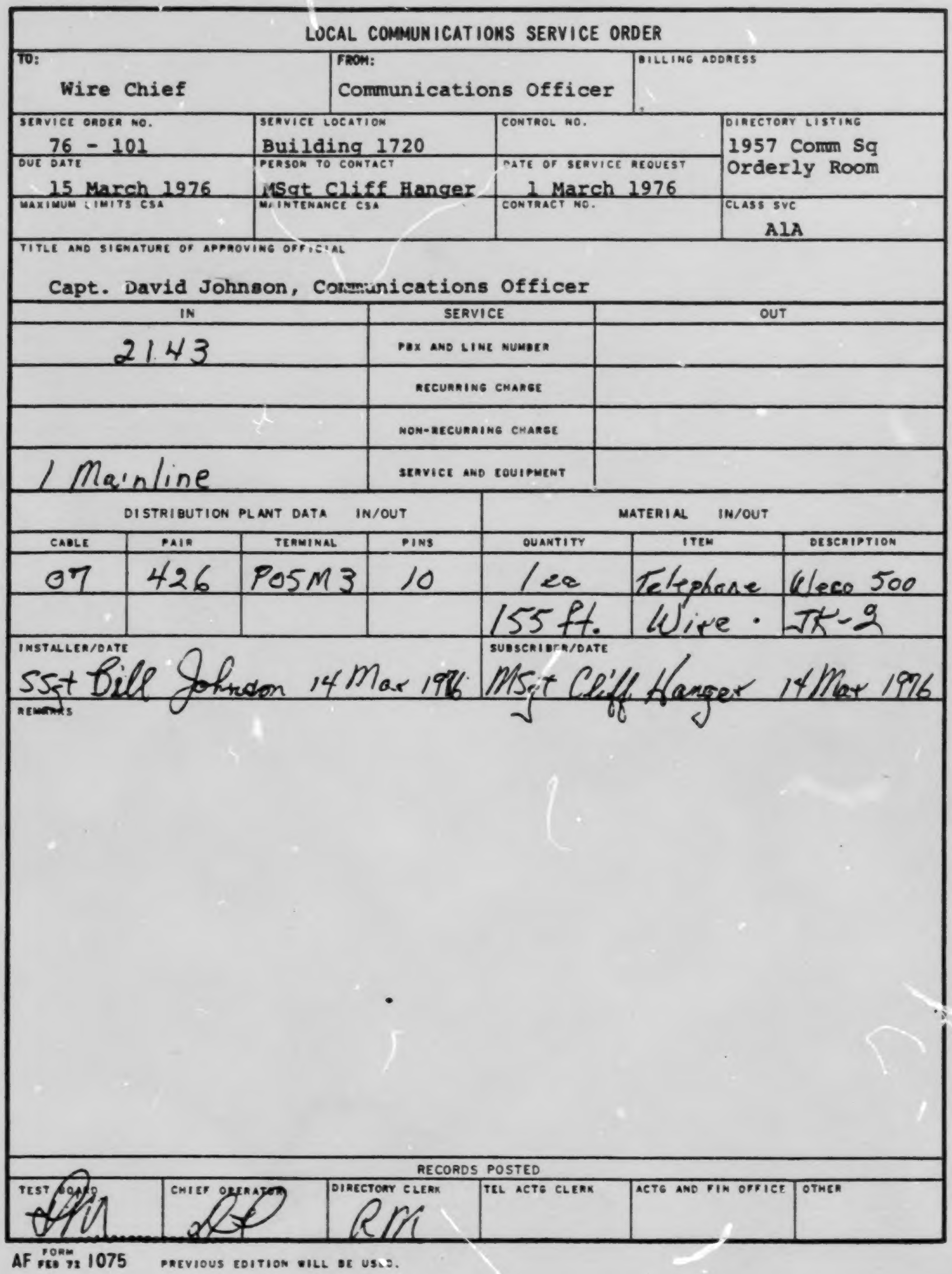
14. LINE RELAY LF 3A 87

15. MISCELLANEOUS

AFTO FORM 121 MAY 73 PREVIOUS EDITIONS ARE OBSOLETE.

TELEPHONE EQUIPMENT LINE RECORD

Figure 5-10. AFTO Form 121.



LOCAL COMMUNICATIONS SERVICE ORDER

TO: Wire Chief	FROM: Communications Officer	BILLING ADDRESS

SERVICE ORDER NO. 76 - 101	SERVICE LOCATION Building 1720	CONTROL NO.	DIRECTORY LISTING 1957 Comm Sq Orderly Room
DUE DATE 15 March 1976	PERSON TO CONTACT MSgt Cliff Hanger	DATE OF SERVICE REQUEST 1 March 1976	
MAXIMUM LIMITS CSA	MAINTENANCE CSA	CONTRACT NO.	CLASS SVC A1A

TITLE AND SIGNATURE OF APPROVING OFFICIAL

Capt. David Johnson, Communications Officer

IN	SERVICE	OUT
2143	PBX AND LINE NUMBER	
	RECURRING CHARGE	
	NON-RECURRING CHARGE	
1 Mainline	SERVICE AND EQUIPMENT	

DISTRIBUTION PLANT DATA IN/OUT				MATERIAL IN/OUT		
CABLE	PAIR	TERMINAL	PINS	QUANTITY	ITEM	DESCRIPTION
07	426	P05M3	10	1 ea	Telephone	Weco 500
				155 ft.	Wire	JK-2

INSTALLER/DATE SSgt Bill Johnson 14 Mar 1976	SUBSCRIBER/DATE MSgt Cliff Hanger 14 Mar 1976

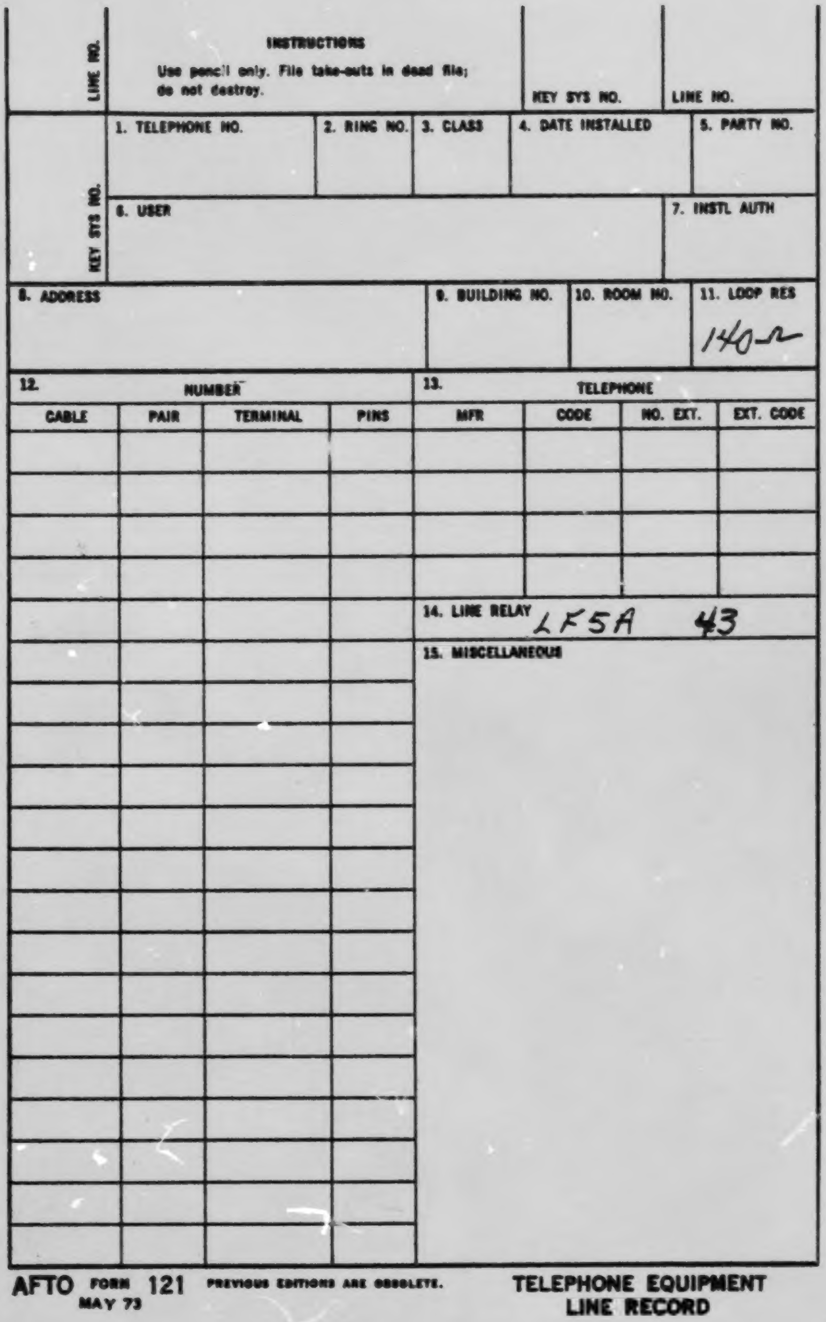
REMARKS

RECORDS POSTED

TEST BOARD	CHIEF OPERATOR	DIRECTORY CLERK	TEL ACTG CLERK	ACTG AND FIN OFFICE	OTHER
		RM			

AF FORM FEB 72 1075 PREVIOUS EDITION WILL BE USED.

Figure 5-11. AF Form 1075 (objective 230, exercise 1).



LINE NO.

INSTRUCTIONS

Use pencil only. File take-outs in dead file; do not destroy.

KEY SYS NO.

LINE NO.

KEY SYS NO.

1. TELEPHONE NO.

2. RING NO.

3. CLASS

4. DATE INSTALLED

5. PARTY NO.

6. USER

7. INSTL AUTH

8. ADDRESS

9. BUILDING NO.

10. ROOM NO.

11. LOOP RES 140Ω

12. NUMBER				13. TELEPHONE			
CABLE	PAIR	TERMINAL	PINS	MFR	CODE	NO. EXT.	EXT. CODE

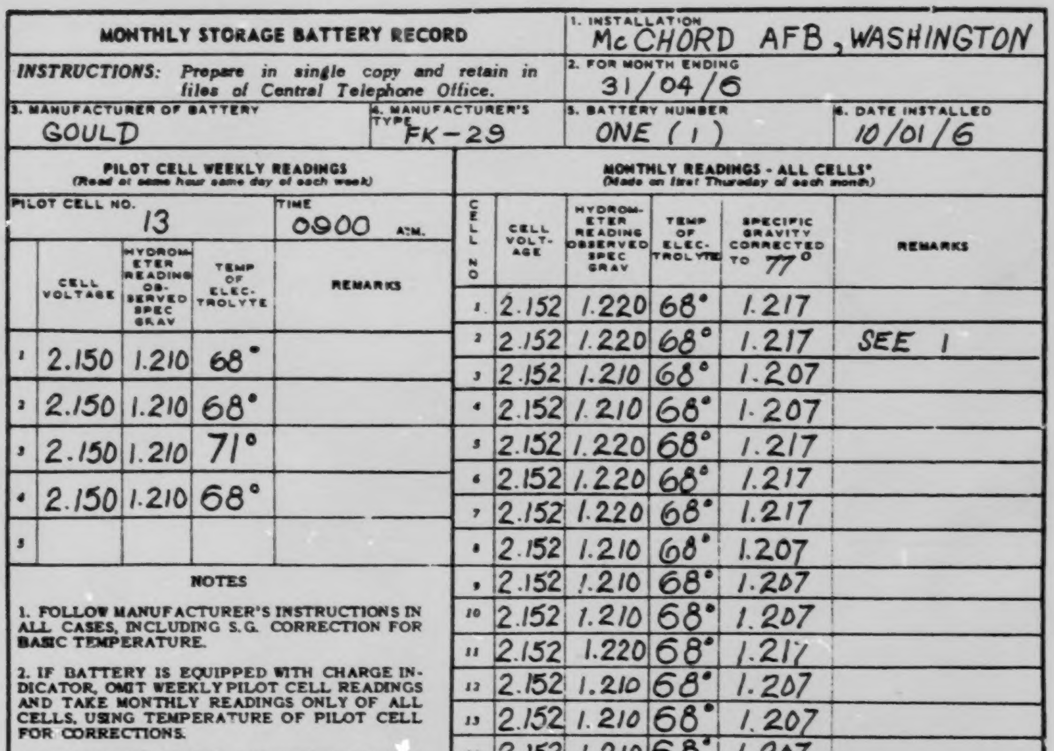
14. LINE RELAY LF5A 43

15. MISCELLANEOUS

AFTO FORM 121 MAY 73 PREVIOUS EDITIONS ARE OBSOLETE.

TELEPHONE EQUIPMENT LINE RECORD

Figure 5-12. AFTO Form 121 (objective 230, exercise 1).



MONTHLY STORAGE BATTERY RECORD

INSTRUCTIONS: Prepare in single copy and retain in files of Central Telephone Office.

1. INSTALLATION McCHORD AFB, WASHINGTON
2. FOR MONTH ENDING 31/04/6
3. MANUFACTURER OF BATTERY GOULD
4. MANUFACTURER'S TYPE FK-29
5. BATTERY NUMBER ONE (1)
6. DATE INSTALLED 10/01/6

PILOT CELL WEEKLY READINGS
(Read at same hour same day of each week)

PILOT CELL NO. 13

TIME 0900 A.M.

	CELL VOLTAGE	HYDROMETER READING OBSERVED SPEC GRAV	TEMP OF ELECTROLYTE	REMARKS
1	2.150	1.210	68°	
2	2.150	1.210	68°	
3	2.150	1.210	71°	
4	2.150	1.210	68°	
5				

NOTES

1. FOLLOW MANUFACTURER'S INSTRUCTIONS IN ALL CASES, INCLUDING S.G. CORRECTION FOR BASIC TEMPERATURE.

2. IF BATTERY IS EQUIPPED WITH CHARGE INDICATOR, OMIT WEEKLY PILOT CELL READINGS AND TAKE MONTHLY READINGS ONLY OF ALL CELLS, USING TEMPERATURE OF PILOT CELL FOR CORRECTIONS.

3. TO CORRECT SPECIFIC GRAVITY READINGS FOR TEMPERATURE ADD .001 FOR EACH 3° ABOVE OR DEDUCT .001 FOR EACH 3° BELOW MANUFACTURER'S BASIC TEMPERATURE.

4. REPORTING LEAD-CALCIUM GRID BATTERIES: Only record hydrometer readings on individual cells once every six months. Readings should be made prior to equalizing charges.

REMARKS (Indicate cells which have been receiving special attention and reason therefor, also date, rate of charge changed, etc.)

1. ADDED WATER TO CELL #2, 7 MAY 1966.
2. ADDED WATER TO CELL #24, 7 MAY 1966.
3. CHANGED TRICKLE CHARGE RATE FOR END CELLS FROM .8 AMP TO .5 AMP, 7 MAY 1966

MONTHLY READINGS - ALL CELLS*
(Made on first Thursday of each month)

CELL NO	CELL VOLTAGE	HYDROMETER READING OBSERVED SPEC GRAV	TEMP OF ELECTROLYTE	SPECIFIC GRAVITY CORRECTED TO 77°	REMARKS
1	2.152	1.220	68°	1.217	
2	2.152	1.220	68°	1.217	SEE 1
3	2.152	1.210	68°	1.207	
4	2.152	1.210	68°	1.207	
5	2.152	1.220	68°	1.217	
6	2.152	1.220	68°	1.217	
7	2.152	1.220	68°	1.217	
8	2.152	1.210	68°	1.207	
9	2.152	1.210	68°	1.207	
10	2.152	1.210	68°	1.207	
11	2.152	1.220	68°	1.217	
12	2.152	1.210	68°	1.207	
13	2.152	1.210	68°	1.207	
14	2.152	1.210	68°	1.207	
15	2.152	1.210	68°	1.207	
16	2.152	1.220	68°	1.217	
17	2.152	1.210	68°	1.207	
18	2.152	1.220	68°	1.217	
19	2.152	1.220	68°	1.217	
20	2.152	1.220	68°	1.217	
21	2.152	1.220	68°	1.217	
22	2.152	1.220	68°	1.217	
23	2.152	1.220	68°	1.217	
24	2.240	1.220	68°	1.217	SEE 2
25	2.240	1.220	68°	1.217	
26	2.240	1.220	68°	1.217	SEE 3

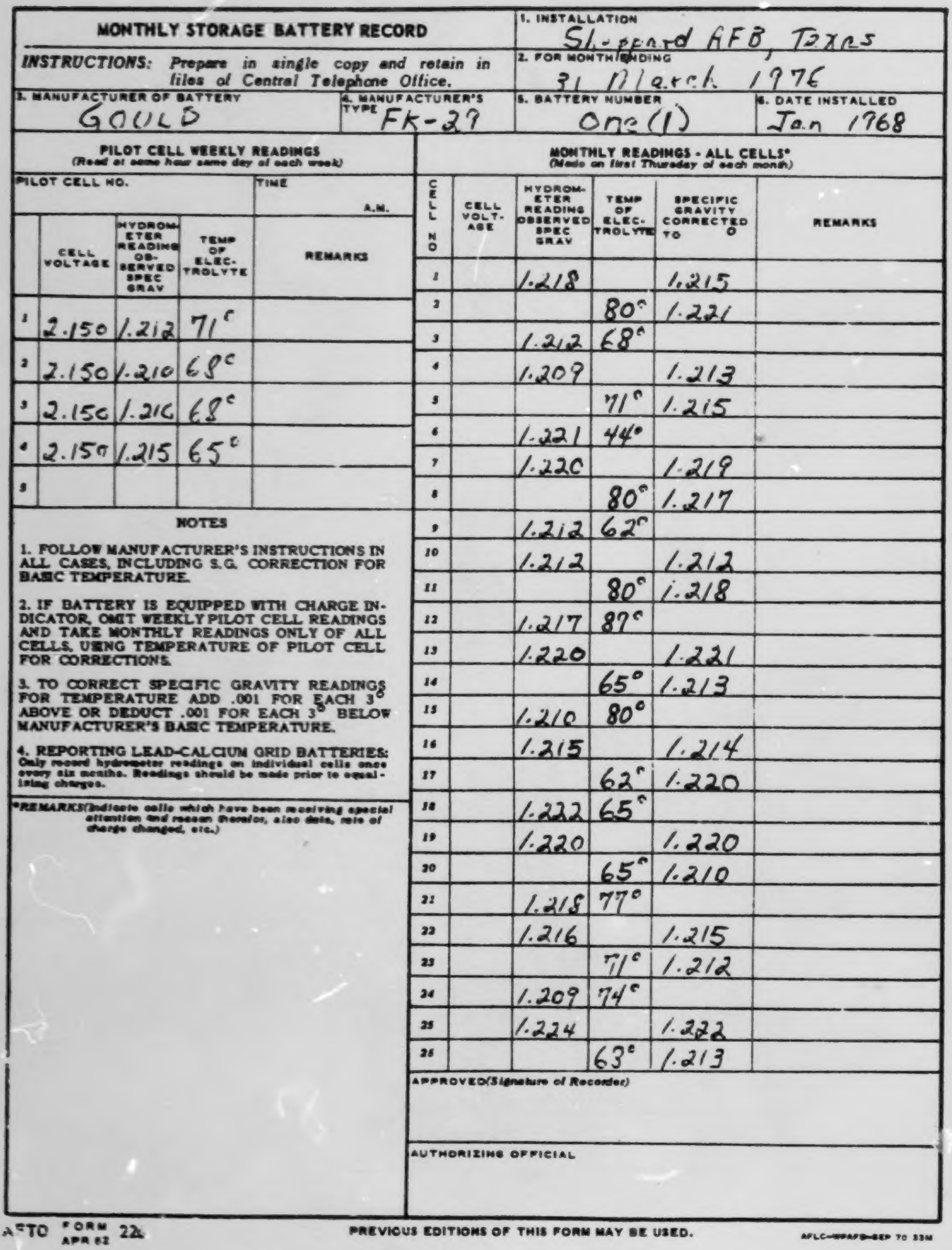
APPROVED (Signature of Recorder) A. Murphy S/SGT

AUTHORIZING OFFICIAL B. Mitchell 1/LT

AFTO FORM APR 62 226

PREVIOUS EDITIONS OF THIS FORM MAY BE USED.

Figure 5-13. AFTO Form 226.



MONTHLY STORAGE BATTERY RECORD

INSTRUCTIONS: Prepare in single copy and retain in files of Central Telephone Office.

1. INSTALLATION: Sheppard AFB, Texas
2. FOR MONTH ENDING: 31 March 1976
3. MANUFACTURER OF BATTERY: GOULD
4. MANUFACTURER'S TYPE: FK-27
5. BATTERY NUMBER: One (1)
6. DATE INSTALLED: Jan 1968

PILOT CELL WEEKLY READINGS
(Read at same hour same day of each week)

PILOT CELL NO.

TIME A.M.

	CELL VOLTAGE	HYDROMETER READING OBSERVED SPEC GRAV	TEMP OF ELECTROLYTE	REMARKS
1	2.150	1.212	71°	
2	2.150	1.210	68°	
3	2.150	1.216	68°	
4	2.150	1.215	65°	
5				

NOTES

1. FOLLOW MANUFACTURER'S INSTRUCTIONS IN ALL CASES, INCLUDING S.G. CORRECTION FOR BASIC TEMPERATURE.

2. IF BATTERY IS EQUIPPED WITH CHARGE INDICATOR, OMIT WEEKLY PILOT CELL READINGS AND TAKE MONTHLY READINGS ONLY OF ALL CELLS, USING TEMPERATURE OF PILOT CELL FOR CORRECTIONS.

3. TO CORRECT SPECIFIC GRAVITY READINGS FOR TEMPERATURE ADD .001 FOR EACH 3° ABOVE OR DEDUCT .001 FOR EACH 3° BELOW MANUFACTURER'S BASIC TEMPERATURE.

4. REPORTING LEAD-CALCIUM GRID BATTERIES: Only record hydrometer readings on individual cells once every six months. Readings should be made prior to equalizing charges.

*REMARKS (Indicate cells which have been receiving special attention and reason therefor, also date, rate of charge changed, etc.)

MONTHLY READINGS - ALL CELLS*
(Made on first Thursday of each month)

CELL NO	CELL VOLTAGE	HYDROMETER READING OBSERVED SPEC GRAV	TEMP OF ELECTROLYTE	SPECIFIC GRAVITY CORRECTED TO °	REMARKS
1		1.218		1.215	
2			80°	1.221	
3		1.212	68°		
4		1.209		1.213	
5			71°	1.215	
6		1.221	44°		
7		1.220		1.219	
8			80°	1.217	
9		1.212	62°		
10		1.212		1.212	
11			80°	1.218	
12		1.217	87°		
13		1.220		1.221	
14			65°	1.213	
15		1.210	80°		
16		1.215		1.214	
17			62°	1.220	
18		1.222	65°		
19		1.220		1.220	
20			65°	1.210	
21		1.218	77°		
22		1.216		1.215	
23			71°	1.212	
24		1.209	74°		
25		1.224		1.222	
26			63°	1.213	

APPROVED (Signature of Recorder)

AUTHORIZING OFFICIAL

AFTO FORM APR 62 226 PREVIOUS EDITIONS OF THIS FORM MAY BE USED. AFLC—WPAFB—SEP 70 33M

Figure 5-14. AFTO Form 226 (objective 231, exercise 1).

The rest of the form entries on the circuit layout record are quite simple. In the Location block of the form you enter, for a particular circuit, its originating and final terminating point. In the Control Office block, enter the office which has primary control over the circuit. The notes or drawings block on the front of the card is as you can see, used to record special notes of significance of a drawing of the circuit.

There is also a TROUBLE REPORT block on the back of the card which contains six columns (see fig. 5-8). All troubles reported for a circuit are recorded in this block. In the DATE BY column enter the date the trouble is reported and the initials of the person reporting the trouble. In the TIME and LOC columns record the time the trouble is reported and the location of the reported trouble. In the TROUBLE column record the trouble and your initials if you are the one who received the report. In the TIME CLEARED and DATE BY columns enter the time and date the trouble is cleared and the initials of the repairman who clears the trouble.

There is also a DRAWINGS block on the back of the form; this is for a drawing of the circuit or a continuation of a drawing on the front of the form.

Exercise (229):

1. Use the information below to annotate the appropriate blocks of the circuit layout record/trouble report, figure 5-9.

Circuit XK5V is a teletype circuit; it is located in the 327th Fighter Operations building 1060, room 3, and goes off-base via tech control. Cable 07, pair 135 is the transmit pair and cable 07, pair 136 is the receive pair going to the exchange (building 742) from building 1060. It cross-connects at the exchange and goes to tech control (building 121) via cable 01, pair 17 is the transmit and pair 18 is the receive going to tech control, which is the control office.

230. Given information extracted from AF Forms 1075, make entries on AFTO Forms 121 and identify other AFTO forms affected by the entries.

Line Record, AFTO Form 121. The line record form is used to maintain a subscriber's telephone line. With the exclusion of a few entries, the same information appears on this record as that appearing on the telephone communications service order (AF Form 1075). Figure 5-10 shows the AFTO Form 121. Referring to the line record in figure 5-10 and the communications service order in figure 5-2, you can compare and see that entries 1, 3, 4, 5, 6, 7, 8, 9, 10, and 12 of the line record form can be filled out from the communications service order.

We will briefly explain those entries that cannot be filled out by referring to the communications service order. In item 11 enter the loop resistance of the subscriber's line. Usually the reading of the loop resistance is obtained with a Wheatstone bridge. In item 13 you enter information pertaining to the telephone instrument. The manufacturer of the instrument, Western Electric (WECO), is entered. Also, an entry is made indicating that the telephone is a wall or desk type (W or D). Furthermore, note that the code of the telephone (500) is entered. In item 14 enter the number of the line relay associated with the subscriber's telephone. Item 15 is reserved for miscellaneous information. For instance, if the telephone instrument has a two-way key, enter that information in the miscellaneous block.

The reverse side of the line record card (not shown) is used to record all troubles reported on a subscriber's telephone line. Columns are provided to show the date and time the trouble was reported, who reported the trouble, the trouble found, its cause, and the work done to correct it. Also spaces are provided to enter the date and time the trouble was cleared and who cleared the trouble.

Exercise (230):

1. Use the information contained in the AF Form 1075, figure 5-11, to annotate the line record card, figure 5-12.

231. Given a partially complete AFTO Form 226 and the necessary information, make appropriate entries and calculations.

Monthly Storage Battery Record, AFTO Form 226. The purpose of a battery record is to maintain, on a monthly basis, a historical record of the condition of the central office batteries. Figure 5-13 illustrates the central office battery record. In reference to the figure, you can see that the form is designed to record all pertinent information for battery cells. For instance, under the heading, Monthly Reading—All Cells, entries are made for each cell of a 26-cell battery.

Reading from left to right for cell 1, you can tell that provisions are made on the record to enter the "cell voltage," "observed specific gravity," and "temperature" of the electrolyte in the battery cell.

In the left-hand portion of the form notice the wording: Pilot Cell Weekly Readings. If your central office batteries do not have a battery charge indicator, you should record a pilot cell weekly reading. The number of the cell you choose is determined by your supervisor or yourself. (Usually it's the cell closest to the middle of the battery.) Enter the cell number in the Pilot Cell No. block. Also enter the exact time you read the cell as indicated in the Time block of the storage battery record in figure 5-13. The rest of the entries for the pilot cell are entered under the Cell Voltage, Hydrometer Reading Observed Spec Grav, and Temp of Electrolyte blocks. As you can see, no specific gravity corrections are made for pilot cells.

The rest of the battery record in figure 5-13 is self-explanatory, such as the battery number, manufacturer, name of battery, etc. Notice the **Remarks** columns. You can see that the information contained in them is flexible. Any information pertinent to the condition of the batteries can be entered in these columns.

Exercise (231):

1. Use the information below to complete the AFTO Form 226 (fig. 5-14), and make necessary calculations.
   a. The voltage of all cells is 2.15 volts.
   b. The manufacturer's basic temperature is 71°.

CHAPTER 6

Manual Central Office Equipment

DO YOU REMEMBER when all you had to do to make a phone call was to lift the handset to your ear? If you have never experienced this yourself, you have probably seen it in the movies or on TV. With the coming of dial and electronic switching systems, we don't give the old manual systems much thought these days. The Air Force still has some manual telephone systems in use today. These manual systems meet certain needs more economically and just as reliable as the newer automatic systems.

At many of the small Air Force radar stations the AN/FTA-13 manual telephone system is used. Compared to the automatic systems you studied in Tech School, this system's circuit operations are less complicated; it has fewer components and requires less test equipment for the performance of PMIs and maintenance.

6-1. System Components

In order to inspect or maintain the AN/FTA-13 manual telephone, you first need to know what it looks like, and the basic purpose and function of its major components.

232. Given a list of components and statements of purpose or functions, match the statements to the proper components.

The purpose of the AN/FTA-13 manual telephone system is to fulfill the communications requirements of radar stations and their related radar networks. It provides for selective intercommunication among site personnel. Communication by telephone line or by control of radio link with radar shelters, information centers, and inflight aircraft are also capabilities of this particular system. The backbone of this system is probably somewhat different from others you have seen or studied. In addition to the PBX switchboard, this system uses an operator's telephone circuit (10 line unit).

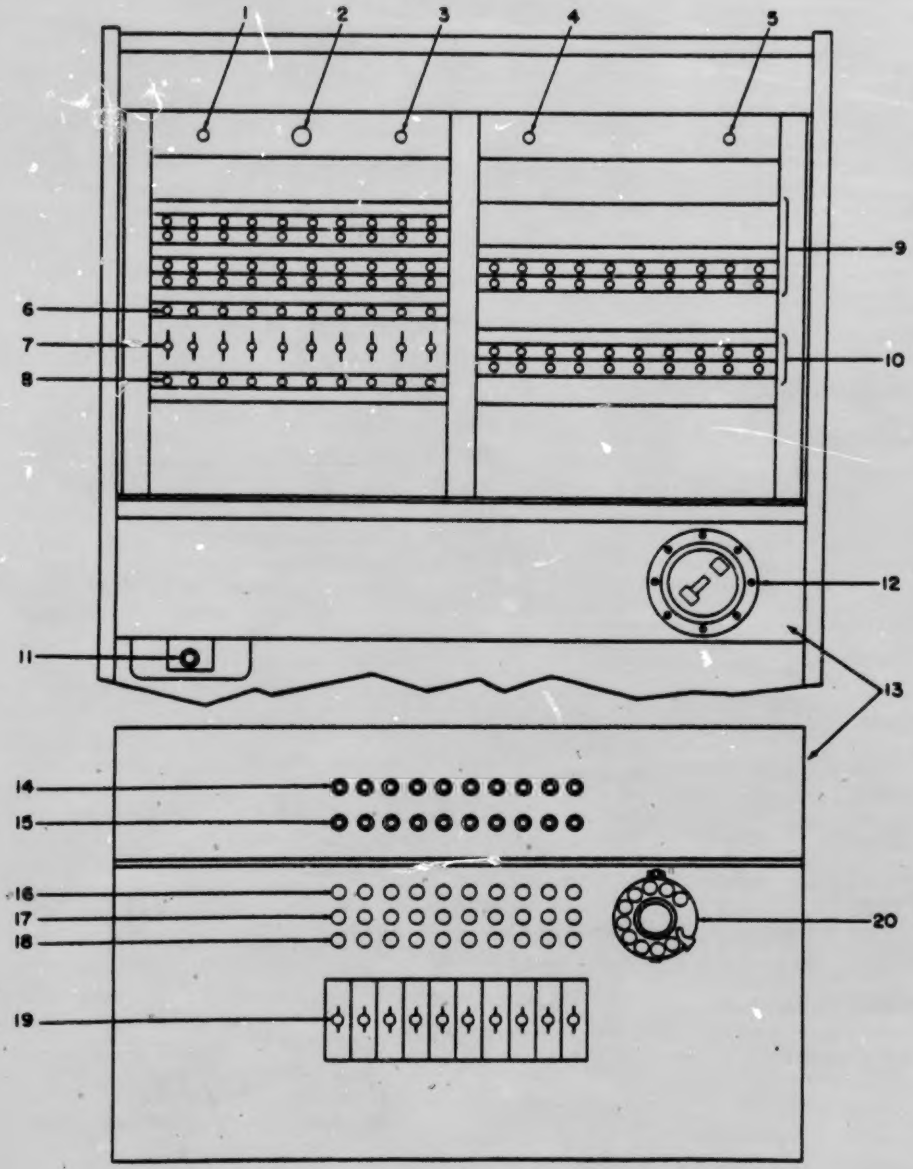
Switchboard. Since the switchboard is normally the first component thought of, when manual telephone systems are mentioned, we will start there.

Face equipment. The face equipment of the switchboard (see fig. 6-1) includes the jacks and lamps associated with magneto line and common battery line circuits. The lamps, jacks, and dial keys for trunk circuits as well as a hand generator, alarm lamps, night alarm, and position switches are also part of the face equipment.

Keyshelf. The switchboard keyshelf seen in figure 6-1 contains many of the components found on the attendant's cabinet in an automatic exchange. Some of the different items are an additional row of (magneto) supervisory lamps and the talk and ring functions which are handled by one key. A key for the monitor function is not needed. The operator can monitor calls by operating the talk key for a given cord and not operating the push to talk key on his handset. Without the circuitry located on the relay gate, at the rear of the switchboard, the rest is useless. The relay gate contains the universal cord circuits and the switchboard circuitry for magneto, common battery, and trunk circuits.

Main Distributing Frame (MDF). The main distributing frame for this system is similar to others you have seen; it consists of two sections. They may be located side by side or in two locations within the exchange. Section one (fig. 6-2) is similar to the MDF in an automatic telephone exchange. The vertical side is equipped with protectors, three verticals of one hundred and one protectors, for three hundred outside terminations. A protector alarm circuit, similar to those you saw in Tech School is also included. The horizontal side of section one has ten 2 x 20 terminal blocks, to which circuits from the relay rack are terminated. Section one of the MDF is used to cross-connect the outside lines to the relay rack circuitry.

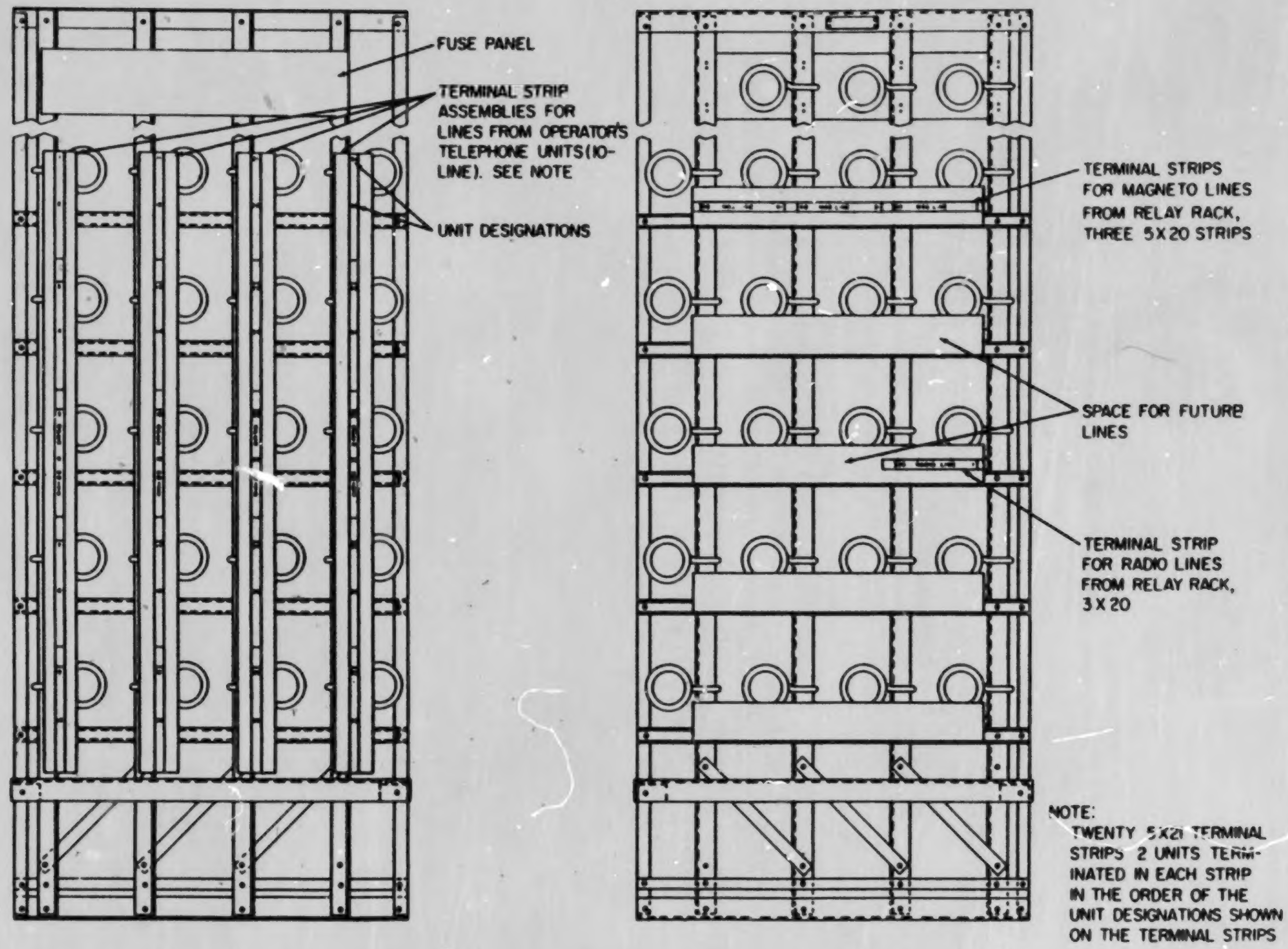
Section two (fig. 6-3) of the MDF can be compared to the intermediate distributing frame (IDF) in an automatic exchange. The vertical side has twenty 5 x 21 terminal blocks which can terminate up to 400 lines from the operator's telephone units (10 line). The horizontal side has three 5 x 20 terminal blocks which connect to 60



1. **Night Alarm Switch**
2. **Fuse Alarm Lamp**
3. **Fuse Alarm Switch**
4. **Generator Switch**
5. **Position Switch**
6. **Lamps - Trunk Lines**
7. **Dial Keys**
8. **Jacks - Trunk Lines**
9. **Lamps and Jacks - Common Battery Lines**
10. **Lamps and Jacks - Magneto Lines**
11. **Operator's Jack**
12. **Hand Generator**
13. **Key Shelf**
14. **Answering Cords**
15. **Calling Cords**
16. **Magneto Supervisory Lamps**
17. **Answering Supervisory Lamps**
18. **Calling Supervisory Lamps**
19. **Talk-Ring Keys**
20. **Dial**

HC—018

Figure 6-1. PBX switchboard, AN/FTA-13.


FUSE PANEL
TERMINAL STRIP ASSEMBLIES FOR LINES FROM OPERATOR'S TELEPHONE UNITS(10-LINE). SEE NOTE
UNIT DESIGNATIONS
TERMINAL STRIPS FOR MAGNETO LINES FROM RELAY RACK, THREE 5X20 STRIPS
SPACE FOR FUTURE LINES
TERMINAL STRIP FOR RADIO LINES FROM RELAY RACK, 3X20

NOTE:
TWENTY 5X21 TERMINAL STRIPS 2 UNITS TERMINATED IN EACH STRIP IN THE ORDER OF THE UNIT DESIGNATIONS SHOWN ON THE TERMINAL STRIPS

HC-009

Figure 6-2. Main distributing frame, section 1.

ring down (magneto) circuits in the relay rack and one 3 x 20 terminal block connected to the radio control circuits in the relay rack. A fuse panel and fuse alarm control for the operator's telephone units are also located on section two.

Telephone Test Set. The telephone test set is nothing more than a test desk. Figure 6-4 shows the face equipment and test panel; figure 6-5 shows the rear view. We discuss the telephone test set later.

Operator's Telephone Circuit (10 Line Unit). The operator's telephone unit, figure 6-6, allows direct communication between the operating posts of the radar station and selected radio channels and magneto line telephone stations. It is equipped with the necessary keys and supervisory lamps for making outgoing calls and answering incoming calls from the telephone and radio channels connected to it. It also contains a night alarm

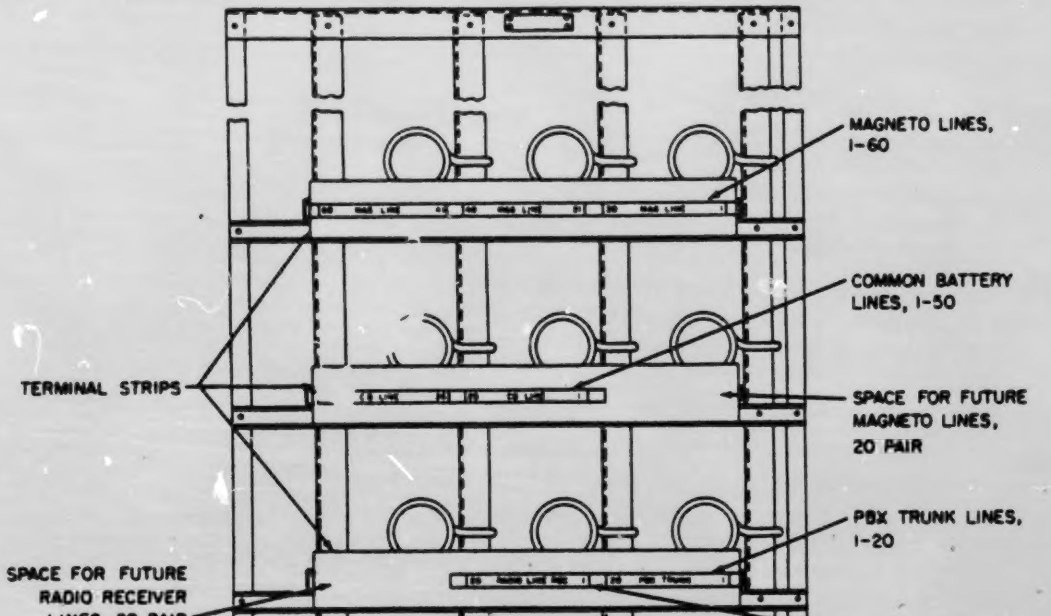

MAGNETO LINES, 1-60
COMMON BATTERY LINES, 1-50
TERMINAL STRIPS
SPACE FOR FUTURE MAGNETO LINES, 20 PAIR
PBX TRUNK LINES, 1-20
SPACE FOR FUTURE RADIO RECEIVER LINES, 20 PAIR
RADIO RECEIVER LINES, 1-20
PBX MAGNETO LINES, 1-20
SPACE FOR FUTURE RADIO TRANSMITTER LINES, 20 PAIR
RADIO TRANSMITTER LINES, 1-20
SPACE FOR FUTURE RADIO CONTROL LINES, 20 PAIR
SPARE TERMINALS, 20 PAIR
RADIO CONTROL LINES, 1-20
HC-008

Figure 6-3. Main distributing frame, section 2.

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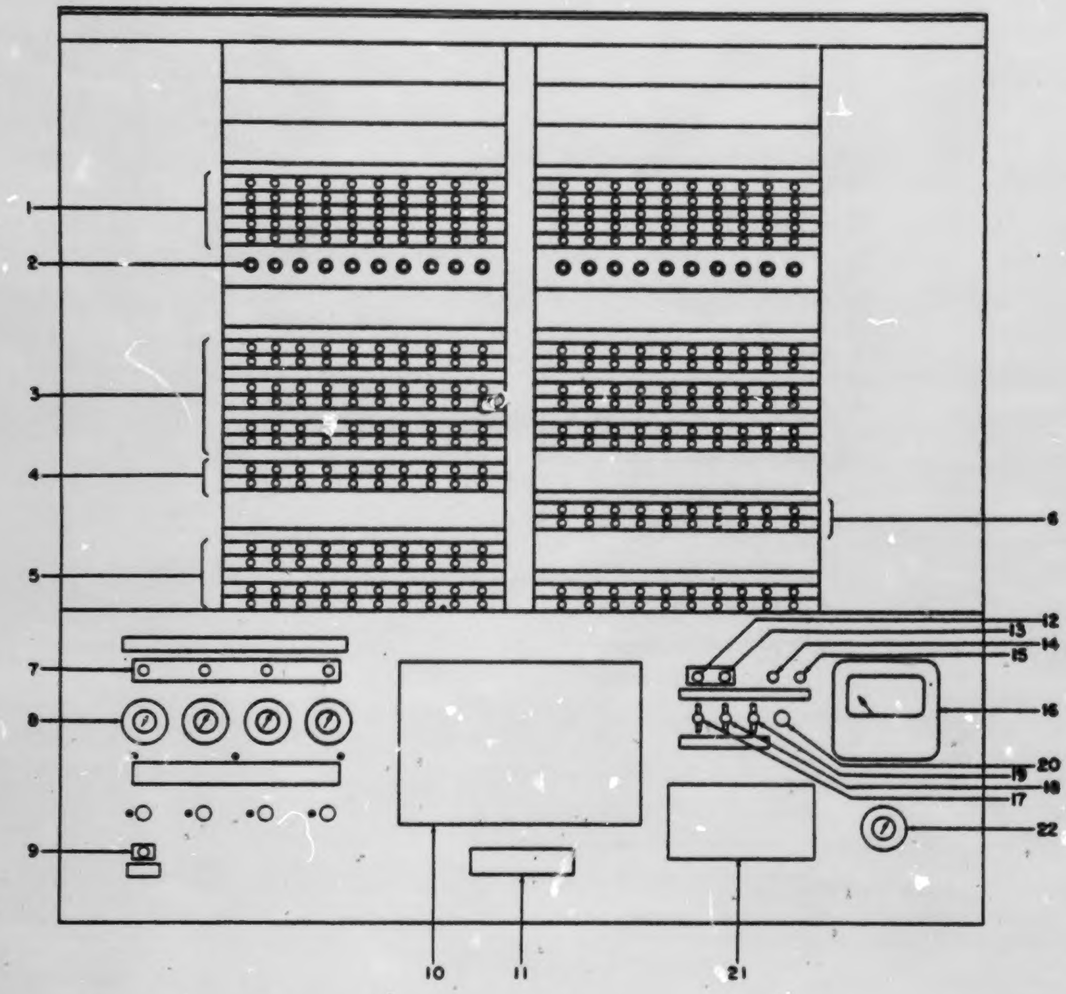

1.	Radio Line Jacks	12.	"TALK" Jack
2.	Radio Line Toggle Switches	13.	"TEST" Jack
3.	Magneto Line Jacks	14.	Supervisory Lamp
4.	Switchboard Magneto Line Jacks	15.	"FUSE ALARM" Lamp
5.	Common Battery Line Jacks	16.	Voltmeter
6.	Trunk Line Jacks	17.	"TALK-RING" Key
7.	Recording Jacks	18.	"SUBS BATT - TEST REV" Key
8.	Selector Switches - Radio Channels	19.	"LAMP REV" Key
9.	Operator's Jack	20.	"NIGHT ALARM" Switch
10.	Wheatstone Bridge	21.	Operating Instructions
11.	Nameplate	22.	Selector Switch - Test Circuit

HC—019

Figure 6-4. Test board (panel), face equipment.

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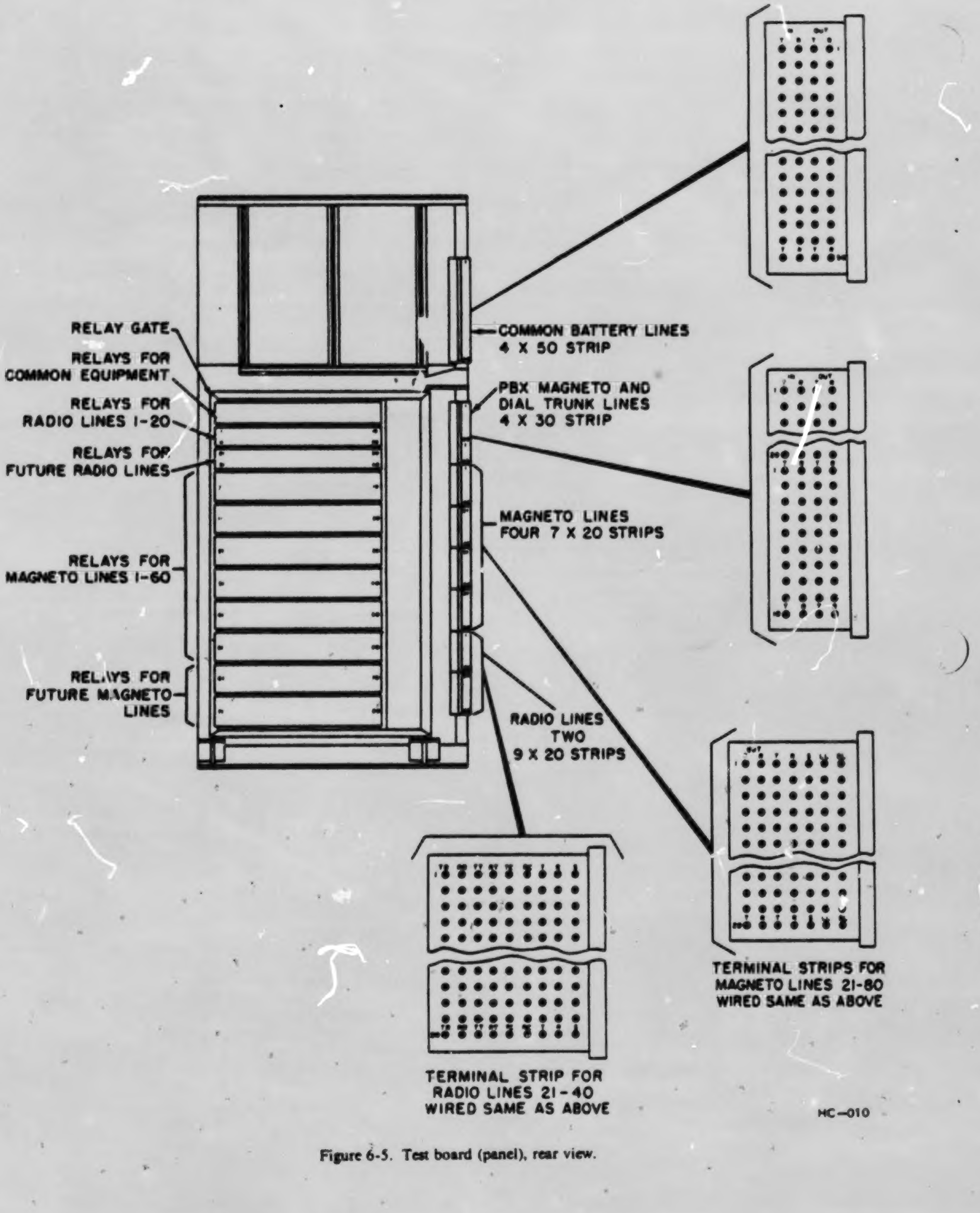

RELAY GATE
RELAYS FOR COMMON EQUIPMENT
RELAYS FOR RADIO LINES 1-20
RELAYS FOR FUTURE RADIO LINES
RELAYS FOR MAGNETO LINES 1-60
RELAYS FOR FUTURE MAGNETO LINES
COMMON BATTERY LINES 4 X 50 STRIP
PBX MAGNETO AND DIAL TRUNK LINES 4 X 30 STRIP
MAGNETO LINES FOUR 7 X 20 STRIPS
RADIO LINES TWO 9 X 20 STRIPS
TERMINAL STRIPS FOR MAGNETO LINES 21-80 WIRED SAME AS ABOVE
TERMINAL STRIP FOR RADIO LINES 21-40 WIRED SAME AS ABOVE
HC-010

Figure 6-5. Test board (panel), rear view.

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circuit which provides audible signaling of incoming calls and jacks for a handset or handset-headset.

Power Supply. The PP-1408/FTA-13 power supply is equipped with four 6-volt storage batteries, a rectifier section for charging the battery and a vibrating reed-type frequency converter for converting the primary AC source to 75 to 90 volts, 20-hertz ringing current.

Relay Rack. The relay rack serves as a switching station for applying signal or ringing current on incoming or outgoing calls to magneto lines and for switching from receive to transmit on radio channels. It also contains a wire chief's test panel and toggle switches for control of the radio transmitter battery.

The relay rack is equipped with 60 ring-down relays and 60 ringing relays for magneto circuits. It is also equipped with 20 ground-to-air switching relays for the radio channels; 20 battery control switches for the radio transmitters; 4 recorder jacks and associated rotary switches.

Equipment Relationships. There are many ways this system can be arranged; a typical arrangement is seen in figure 6-7.

Figure 6-7 shows operator's 10 line telephone units, connect by cable, through the MDF (section two) to magneto (mag) and radio line equipment mounted in the relay rack.

Looking at figure 6-7 from the right, you see section one of the MDF. The telephones for the rest of the site offices, barracks, and shops are connected through the protector assembly to terminal blocks on the horizontal side of the frame to magneto and common battery (CB) lines and to transmit, receive, and control circuits (radio) located in the relay rack.

At the bottom of figure 6-7 are the switchboard and the power unit. The switchboard is cabled to the CB line equipment in the relay rack and also to a limited number of mag lines. The power supply furnishes DC and ringing current to the relay rack and the switchboard and DC (battery and ground) to the fuse panel on section two of the MDF and a ground only to section one of the MDF.

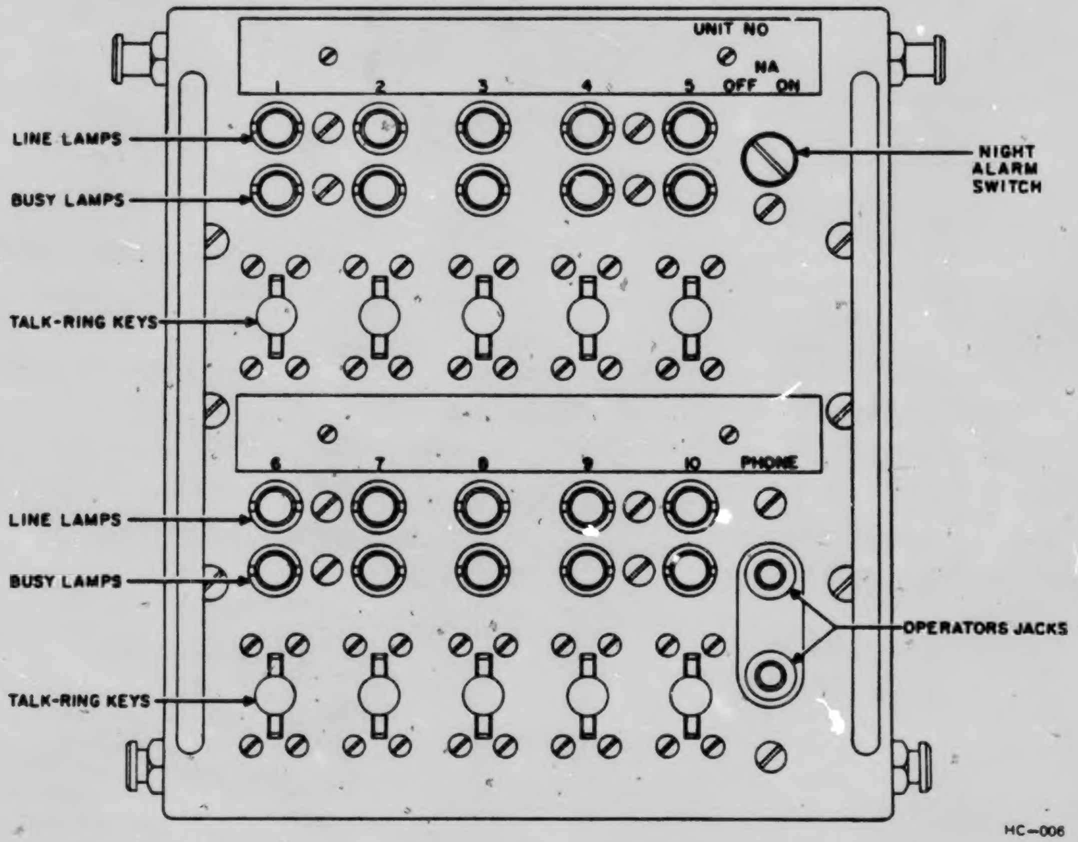

Figure 6-6. Operator's telephone unit, 10 line.

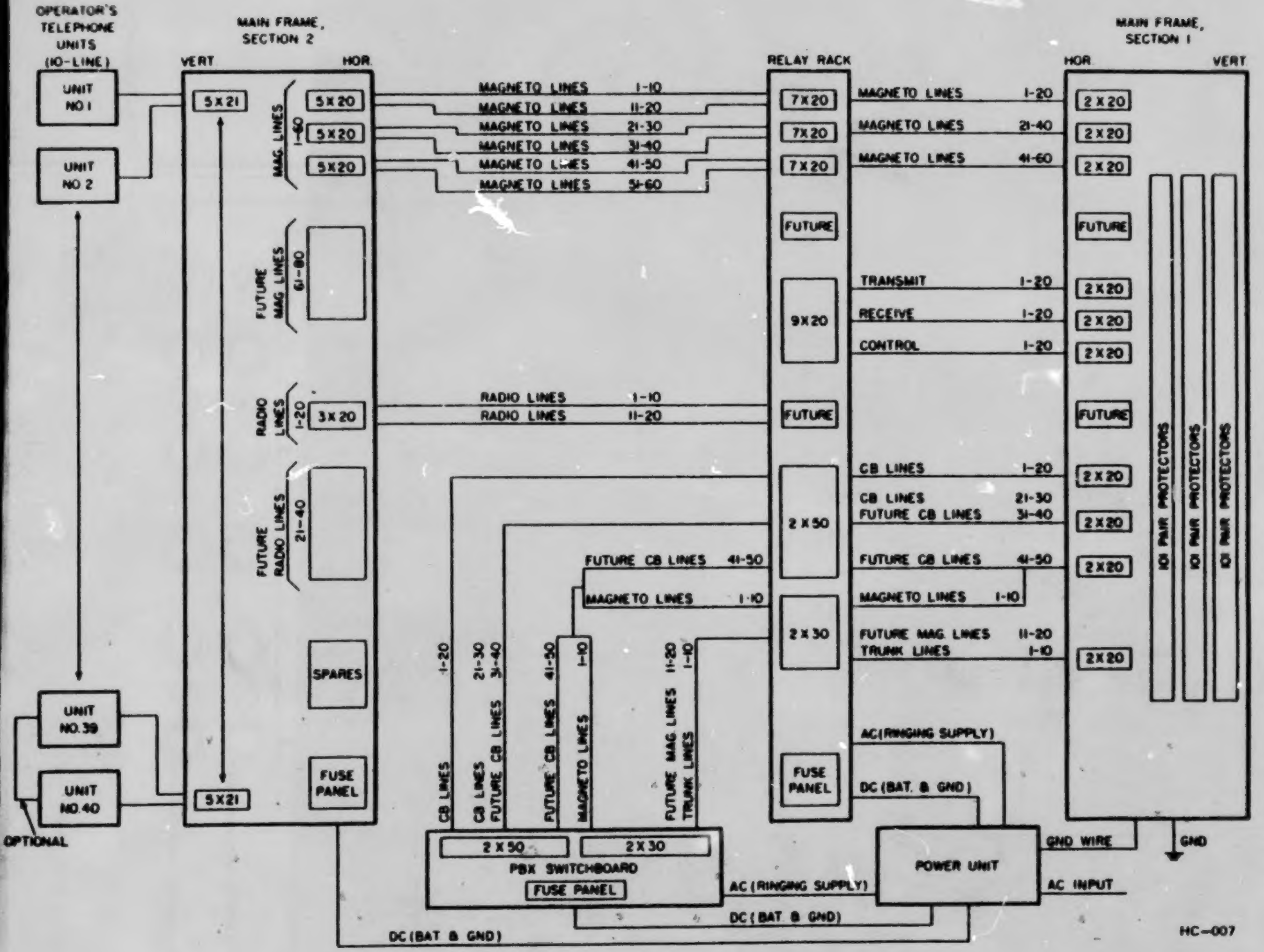

Figure 6-7. Typical configuration of An/FTA-13 manual telephone system.

Exercises (232):

Match the statements (column B) about manual telephone systems to the components (column A).

	Column A		*Column B*
___ 1.	Switchboard.	a.	Serves as a switching station for the system.
___ 2.	Operator's telephone circuit (10 line unit).	b.	Terminates the site subscriber's lines to equipment terminal blocks.
___ 3.	MDF (section one).	c.	Has access to magneto lines and radio lines.
___ 4.	Power supply.	d.	Processes calls for CB and magneto line subscribers.
___ 5.	Relay rack.	e.	Terminates the operator's telephone units to magneto and radio lines.
___ 6.	MDF (section two).	f.	Provides ringing current and DC to the switchboard.

6-2. Switchboard and Associated Circuits

Now that you have seen the system's parts, functions, and basic arrangement, you need some idea of how the circuitry of the various parts work.

233. Use the foldouts discussed in this segment to identify the actions that occur in the switchboard and associated circuits during operation and state what effects those actions have on associated equipment.

In this section we look at these calls: (1) a 10 line unit to a mag line, (2) a mag line call to a 10 line unit, (3) a CB line calling through the switchboard to a mag line, and (4) a mag line calling through the switchboard to a CB line.

Call From a 10 Line Unit to a Mag Line. Foldout 1 is the schematic diagram of the operator's telephone circuit (10 line unit) and foldout 2 is the schematic diagram of the magneto line circuit. Let us assume that an operator needs to talk to the subscriber on line 1 of his 10 line unit. His first move is to see if that line is busy. He does this by looking at the busy (BSY) lamp for that line; if it is not lit he can proceed. Since he is calling a mag line he must signal the called party; he does this by operating the RING-TALK key (lever switch) to the RING position (see foldout 1, lower right-hand corner).

Ring key operated. When the ring key for line one is operated, it places a ground through contacts 1B and 2B of the key, out the S lead to the S lead of the mag line (foldout 2) being called.

Coming into the magneto line circuit from the 10 line unit (left-hand side of foldout 2), the ground on the S lead causes relay RR to operate

Relay RR operates. When relay RR in the mag line circuit operates it closes contacts 2 and 3 and contacts 22 and 23, placing ringing from the generator circuit out to the called line, causing the phone to ring.

Ring key released and talk key operated. After a second or two the operator releases the key from the RING position. This opens contacts 1B and 2B of the ring key (foldout 1) and removes the ground from the S lead in foldout 2. This causes the RR relay in the mag line circuit to release. This does two things: (1) it removes ringing current to the called line because contacts 2 and 3 and contacts 22 and 23 open and (2) it partially closes the transmission path between the operator's unit and the called line because contacts 1 and 2 and contacts 21 and 22 close.

When the 10 line unit subscriber operates the key to the TALK position (foldout 1) the following events happen:

(1) Contacts 6D and 7D close the circuit to relay SW of the 10 line unit it operates.

(2) Contacts 4D and 5D close the circuit to the busy lamp of the circuit in use, causing it to light.

(3) Contacts 2D and 3D and contacts 2C and 3C partially close the transmission path.

Relay SW operates. When relay SW operates it connects the secondary winding of the induction coil to the line, completing the transmission path.

When the called subscriber answers his phone, conversation takes place. The handsets of the calling and called parties are both the push-to-talk type.

Call From a Mag Line to a 10 Line Unit. The subscriber (mag line) connected to line 10 of the 10 line unit initiates a call to the unit by operating the hand generator of his instrument. This places ringing current on the line into the magneto line circuit (foldout 2, right-hand side), causing relay RU to operate to its "X" contacts.

The path that operates the RU relay to its "X" contacts is through contacts 23 and 24 and the b-d winding of the RU relay.

RU relay operates to its "X" contacts. When the RU relay operates to its "X" contacts (1 and 2, and 21 and 22), they close a path to fully operate the RU relay.

RU relay operates fully. RU operates fully and holds operated. Contacts 23 and 24 break, opening the path that operated the RU initially; this action keeps the relay from chattering due to the AC coming in on the line from the calling party. Contacts 3 and 4 of the RU place a ground on the LL (line lamp) lead to the 10 line unit (foldout 1).

Look at foldout 1 and find the LL lead for line 10. The ground comes in on that lead, through the INC lamp to the night alarm (NA) relay winding to battery. The NA relay in the 10 line unit is multipled to all the incoming lamp leads in the unit. The INC lamp lights and the NA relay operates. If the NA switch is operated contacts 3 and 2 of the NA relay close, operating the buzzer; this warns the operator there is an incoming call.

The operator operates the RING-TALK key to the TALK position.

Talk key operated. When the TALK key (foldout 1) is operated it does all of the same things it did in the previous discussion, plus one other. Contacts 4D and 5D, in addition to lighting the busy lamp on the 10 line unit, place the same ground out the BL lead to the magneto line circuit (foldout 2) and shunts the hold path of the RU relay, causing it to release.

RU relay releases. When the RU relay (foldout 2) releases, its 3 and 4 contacts open the incoming lamp circuit of the 10 line unit. Conversation can then take place.

Call From a CB Line to a Magneto Line. In this discussion we use foldout 3, PBX switchboard common battery line circuit; foldout 4, PBX switchboard universal cord circuit; foldout 5, PBX switchboard operator's circuit; and foldout 6, PBX switchboard magneto line circuit. Let us start with foldout 3. Our calling subscriber's line comes into the exchange by way of a vertical protector assembly on section one of the MDF and is cross-connected to a terminal block on the horizontal side of the frame. From the terminal board it is cabled through a pair of test jacks (shown in fig. 6-8) located on the relay rack. For our purpose the subscriber is connected to the T and R leads going to the test jacks.

CB subscriber lifts the handset. When the CB subscriber lifts his handset, it places a loop across the tip (T) and ring (R) leads of the common battery circuit (foldout 3). This closes a path from ground through contacts of the switchboard line jack to battery in the NA circuit. This causes the line (INC) lamp to light.

Switchboard operator answers. The switchboard operator, upon seeing the lighted line lamp, inserts an answer (rear) cord (foldout 4) into the line jack of the circuit. This action opens the contacts of the line jack, and puts out the line lamp. The ground on the sleeve of the line jack makes contact with the sleeve of the answer cord, operating the RS relay in the cord circuit.

Relay RS operates. When relay RS operates its contacts 24 and 25 place battery through its b-d winding on the ring side of the subscriber's line and contacts 21 and 22 place ground through its a-c winding on the tip side of the subscriber's line. Since the subscriber's line is a loop, a path for relay RB is completed. The contacts of relay RB do nothing at this time.

Operator operates talk key. When the switchboard operator operates the talk key, it puts the operator's circuit (foldout 5) across tip and ring of the cord circuit. Notice that the operator's transmission battery is separated/blocked from the calling party's transmission battery (supplied by relay RB in the cord circuit). This is done by capacitors C1 and C2 of the operator's circuit. If the battery were not blocked, relay FB in the cord circuit would operate. Conversation can now take place. Our calling party asks for connection to a switchboard magneto line.

Operator accesses magneto line circuit. The operator plugs the call cord into the proper magneto line circuit (foldout 6). Notice that the sleeve of the mag line jack is open. When the plug (call) is inserted it opens contacts to remove the RU relay (foldout 6) from the circuit and the operator is, for all practical purposes, directly across the called party's line. The operator operates the TALK-RING key (foldout 5) to the RING position, closing a circuit from the ringing generator circuit out the call cord to ring the called party's phone. Notice in foldout 5 that ringing current can only be applied using the call cord. The operator then operates the key to the talk position to see if the called party answers. If he does, the key is returned to the normal position.

Call From a Magneto Line to a CB Line. In order for a magneto line subscriber to signal the switchboard operator he operates the hand generator of his instrument, placing ringing current across tip and ring of the magneto line circuit (foldout 6) through the closed line jack contacts, contacts 23 and 24 of relay RU, and the b-d winding of the RU relay. This causes the RU relay to operate to its X contacts. Contacts 1 and 2 close an operate (full) path for the RU relay.

RU relay operates fully. When the RU relay operates fully it opens its contacts 23 and 24, removing the AC from the upper winding. Contacts 3 and 4 of relay RU close a path through the INC lamp on the switchboard to battery in the switchboard's NA circuit, lighting the INC lamp.

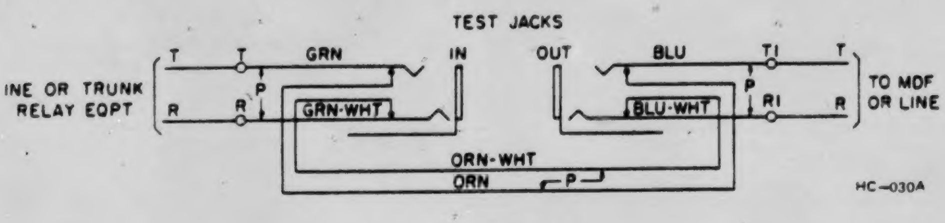

Figure 6-8. Test jack.

Switchboard operator answers. The switchboard operator plugs the answer cord into the magneto line jack. Remember that there is no potential on the sleeve of the line jack. This means that nothing in the cord circuit operates. Inserting the answer cord plug into the line jack opens contacts, releasing the RU relay. When the RU relay releases, the circuit through its contacts 3 and 4 opens the path of the INC lamp. The operator then operates the talk key.

Talk key is operated. When the operator operates the talk key he bridges the operator's circuit (foldout 5) across the transmission path of the cord circuit (foldout 4). A magneto line subscriber is not provided transmission battery; so there is no need for the RS or RB relays in the cord circuit to operate. The operator talks with the calling party and finds out whom he wants to be connect to. In this case it's a CB subscriber.

Operator accesses CB line. When the operator plugs the call cord of the cord circuit (foldout 4) into the line jack of the CB line circuit (foldout 3) the ground on the sleeve of the line jack closes a path to the FS relay in the cord circuit.

Relay FS operates. Contacts 24 and 25 and contacts 21 and 22 of relay FS prepare a path for relay FB. Contacts 1 and 2 of relay FS close a path, lighting the call cord (front) supervisory lamp. This indicates the called party's phone is on the hook and not in use. The operator operates the ring key at this time, connecting ringing current to the called line. The key is then returned to the TALK position for the operator to see if the party has answered.

Called party (CB line) answers. When the common battery subscriber answers, a loop is completed across tip and ring of the line by his phone causing the FB relay in the cord circuit to operate.

FB relay operates. When relay FB operates it contacts 3 and 4 break, opening the path of the lit call cord supervision lamp. Relay FB provides transmission battery to the common battery subscriber.

Exercises (233):

Identify the actions that occur in the circuits indicated below, for the specified part of the circuit operation.

1. Line one receives a call from a magneto line subscriber.
    a. What happens in the magneto line circuit (foldout 2), when the calling party operates his hand generator?

    b. What happens in the operator's telephone circuit (foldout 1), line 1; following the actions in the magneto line circuit? Why?

    c. What happens in the magneto line circuit, when the operator moves the TALK-RING key to the TALK position? Why? (Foldouts 1 and 2.)

    d. What happens in the operator's telephone circuit, when the TALK-RING key is placed in the TALK position? (Foldouts 1 and 2.)

2. A common battery subscriber (foldouts 3 and 4) makes a call to another common battery subscriber.
    a. What happens in the PBX switchboard common battery circuit, when the subscriber goes off-hook? Why?

    b. What happens in the cord circuit, when the switchboard operator answers the call?

    c. What happens in the cord and common battery line circuits, when the operator inserts the call cord into the line jack of the called party?

6-3. Troubleshooting Approach

Have you ever taken your car to a garage to have some trouble fixed? How did the mechanic approach the problem? Did he start replacing parts, hoping he would hit upon the trouble, or did he systematically pin it down to what was really wrong?

Replacing parts until you luck out and clear the trouble is a sorry way to troubleshoot and eventually clear troubles. It wastes time and parts. There is a better way.

In this section we discuss a systematic approach to troubleshooting. It is not a cure-all, and it is not going to clear all your equipment troubles in a flash; it is, however, the best method presently known.

234. From a list of troubleshooting steps and

explanations, match the steps to the proper explanations.

Troubleshooting is a procedure used to locate faults in central office equipment to determine their EXACT cause(s). After locating the cause(s) you make the repairs needed.

We use a six step procedure that has proved itself over the years. The six steps are:

- Recognize.
- Localize.
- Analyze.
- Point-by-point elimination.
- Clear the fault.
- Test.

Recognize. The first step, recognize, in troubleshooting is obvious; you do not fix something that you think is working as it should. You can recognize a trouble in several ways using your senses of sight, sound, smell, and touch.

Sight. This includes visual alarms (lamps) a stepping switch not stepping properly, etc.

Sound. Relays chattering, rotary switches spinning, audible alarms, etc.

Smell. The odor of overheated relay coils, switch magnets, or transformers.

Touch. Excess heat from equipment.

Localize. The next step is localizing the trouble to a major component (specific switch or main circuit). This is done using alarms and test equipment to narrow the possibilities to a specific equipment and trouble.

Analyze. After the trouble is narrowed down to a specific area get the proper schematic diagram(s) and circuit explanation sheets. Now analyze the circuit to determine the possible points of trouble that fit the symptoms: dirty contacts, open windings, broken wires, no battery or ground, etc. A knowledge of system operation helps here.

Point-by-Point Elimination. Now that you have identified the possible points of trouble you must determine, using test equipment, where the problem is. Continuity tests, using a test lamp or test receiver, are excellent for this task. When you get to the point where you do not find the potential that ought to be there, you have almost arrived. Your search may lead you to a circuit that controls the one you first thought was in trouble or it may be no more than dirty relay contacts in the affected circuit.

Clear the Fault. Once you have narrowed down the problem, do what is needed. Burnish the dirty contact; adjust the relay; whatever you must do, do it.

Test. It has been said, "The proof of the pudding is in the tasting." When troubleshooting it is in the testing. You perform an operational system test; this is one to see if you have found and fixed the trouble. If you have, congratulations; if you haven't it is back to point-to-point elimination. Remember it is possible that more than one trouble was in the circuit.

Exercises (234):

Match the list of troubleshooting steps and explanations below, properly in the space provided.

____ 1. Recognize.
____ 2. Localize.
____ 3. Analyze.
____ 4. Point-by-point elimination.
____ 5. Clear the fault.
____ 6. Test.

a. Determine possible trouble points in the circuit.
b. Seeing or hearing alarms; looking at the trouble log.
c. Replacing parts or making adjustments.
d. Determining which circuit in a bay is in trouble.
e. Performing an operational system check.
f. Testing for circuit continuity and/or component operation.

6-4. Troubleshooting Switchboard and Associated Circuits

The moment of truth is here. You have looked at the major components of the manual system, its functions, some of the main circuits, and an approach to troubleshooting.

We cannot actually do it in this course, but since the important part of troubleshooting is done mostly between your ears, let us look at a trouble or two and see if you have it all together.

235. Given switchboard and associated switchboard circuits trouble symptoms, use the foldouts to identify the probable causes of trouble and state corrective action for each.

One of the essentials for troubleshooting any circuit is knowing what the circuit is supposed to do under normal conditions. Being able to read and interpret the schematic diagrams is another. The rest is a matter of systematic approach and being able to select and use test equipment.

Magneto Line Circuit Trouble. Look at foldout 6 while you are reading about the following trouble symptoms. The subscriber complains that he can receive calls, but he cannot make a call.

You recognize the trouble; you have a complaint. Your next step is to localize it. Look at the facts available. The subscriber can receive calls; this tells you that his transmitter, receiver, and battery for transmission are working. You do not know (1) if his hand generator works, (2) if the line jack contacts are clean and/or made when a plug is not in it, (3) if contacts 23 and 24 of relay RU are made and clean, and (4) if the b-d winding of relay RU is good and the RU is operating, etc. Look for other possibilities before going further. The "X" contacts may be bad; the INC lamp may be burned out (open); and contacts 3 and 4 may not be making. These are but a few of the possibilities. Now, where do you start?

Checking the inside possibilities; outside? Why not call the subscriber and ask him to turn his hand generator, after you get off the line, and see if his hand generator works? It is the only item in his intrument that you are not sure of. The best way to do this is by placing a meter across his cable pair. Let us assume that you receive the proper voltage; this means the trouble is in the exchange, either the circuit or switchboard.

Did the RU relay operate? This is easy to check; look at it! If it operated you know (1) that the line jack contacts are made and clean, (2) that contacts 23 and 24 of the RU are clean and made, (3) that the relay winding is good, and (4) that the full operate path of the RU is good.

You have eliminated four of the original possibilities. About the only possibilities left are these: is ground at contact 4 of relay RU; is the INC lamp good; are contacts 3 and 4 of RU making or clean; and is there battery coming from the night alarm circuit? A simple continuity test with a test lamp or test receiver provides the answer.

Exercises (235):

Use the foldout(s) indicated and the trouble symptom(s) given to determine the cause and state the corrective action for each trouble.

1. The magneto line subcriber is connected to line one of an operator's telephone unit. The subscriber can receive calls; but cannot initiate calls. His telephone instrument and the operator's telephone unit are not in trouble.

2. The switchboard operator on position one can hear subscribers, but cannot be heard. The operator's headset, varistor RV1, and repeat coils are good and no fuses are blown. (Foldouts 4 and 5.)

3. On cord circuit one of switchboard position two only magneto line subscribers can be heard when called. No fuses are blown. (Foldouts 3, 4, 5, and 6.)

6-5. Test Board

The test board in this manual system is a panel mounted in the relay rack. It is the central testing point for all the circuits in your exchange.

236. Use the appropriate foldouts to identify the actions that occur in the test board during the performance of tests.

Look at figure 6-4; notice that the top portion of the face equipment contains IN/OUT jacks for all of the different circuits in the system. These jacks are used for testing either the line side or the equipment side of the circuit. These jacks serve the same purpose as a test shoe in an automatic telephone office. Figure 6-8 shows one set of these jacks and how they are wired.

Without a test cord plugged into either jack, the circuit has continuity from the tip conductor on one side to the jacks to the tip conductor on the opposite side of the test jacks. The same holds true for the ring side. When a test cord is plugged into the OUT test jack, the tip and ring conductors are removed from the equipment and placed across tip and ring of the test cord. The same is true, in reverse, if the test cord is plugged into the IN jack instead of the OUT jack.

The test cord we have been discussing has plugs on both ends. You know where to plug one end of it; the other is plugged into the TEST jack on the test panel, figure 6-4. The TEST jack (13 in fig. 6-4) is directly to the right of the TALK jack (12 in fig. 6-4). The TALK jack provides a means of talking on or monitoring the line or equipment side of any telephone circuit. This is done with another double plugged test cord.

Test Keys and Selector Switches. Look at foldout 7; it is the test circuit for the test panel. Compare it with figure 6-4 until you have located all the keys and switches on the face equipment that are a part of the testing circuit.

Notice table A in foldout 7; it contains a list of tests and states the position of the selector switch (22 in fig. 6-4) and what key must be operated.

As you have seen in table A of foldout 7 there are a number of tests that can be performed from this test panel. Let us look at how to make some of the tests and how the test desk circuitry works.

Testing a Magneto Line. Before doing anything you must plug your test cord in the TEST jack on the panel, and plug the other end into the OUT jack of the line being tested. With the test cord plugged in and the selector switch on terminal 1, look at the test circuit; keep in mind that the subscriber's telephone is across the test jack of the circuit.

> NOTE: There are four rows of seven contacts shown for the selector switch. Whatever position the selector switch is turned to, switch contacts A, B, C, and D are all on the same number position.

To come in at the tip (SL) conductor of the test jack you pass through (1) contacts B of the TEST REV key, (2) contact D on terminal 1 of the selector switch, (3) closed contacts C of the TALK key, (4) closed contacts B of the RING key, (5) through the b-d winding of the RU relay and its 23 and 24 contacts, (6) capacitor C4 and contacts A of the RING key, (7) contacts D of the TALK key, (8) contact C in position one of the selector switch, and (9) contacts A of the TEST REV key to the ring conductor (SL-WHT) of the test jack to the instrument.

Do you remember our mag line subscriber earlier in the chapter who could receive but not make phone calls? Let us assume we have the test cord in his circuit. He can receive calls, so let's operate the ring key. By operating the RING key you place ringing current on his line. TRACE THE PATH from the tip conductor of the test jack to the ring conductor. Now, move the key from the RING to the TALK position and trace the circuit. This places the secondary winding of the induction coil in the circuit and when the subscriber answers, you can hear him. By operating the push-to-talk switch on the handset of the test board you can talk to the subscriber and ask him to operate the hand generator on his instrument. You then return the TALK key to the normal position.

When the subscriber operates the generator on his phone it operates the RU relay to its "X" contacts; do you see the path through the b-d winding of the RU and its 23 and 24 contacts? If not, try again, it's there. When the "X" (1 and 2) contacts of RU make, it operates fully and holds to ground on the TALK key. Contacts 23 and 24 open the original operate path of the RU; contacts 3 and 4 close a path that lights the SUPV lamp on the test board.

Now that we know that the subscriber's phone is good we need to look at the inside equipment (foldout 6). You move your test cord to the IN test jack. With no keys operated and the selector switch in position one, operate the ring key and the RU in the mag line circuit should operate. If it does a lot of possible trouble points are eliminated. In any case, you know that the line from the subscriber to his line jack appearance is good and that his instrument is also good. Let's see how to make meter measurements.

Loop Potential Test. Place the selector switch on position two and trace the circuit from the test jack on the test panel. This time the tip conductor is connected to negative (−) side of the meter by means of the selector switch D contact, and the ring conductor is connected to the positive (+) side of the meter by means of the C and A contacts of the selector switch (C and A are strapped together on step 2 of the selector switch). If a battery source is present on the line, such as in a switchboard common battery circuit (foldout 3), the meter will indicate the voltage of the battery. If the battery is reversed, causing the meter to move in the wrong direction, operate the TEST REV key. TRACE THE PATHS BEFORE READING FURTHER.

Let us assume that you are testing the cable pair of a CB instrument for the rest of the tests.

Negative Potential Test. For this test, place the selector switch on step 3. This places a ground potential through contact A of the selector switch to the positive side of the meter and out the tip conductor; if negative battery is present on the tip side of the line, the voltage of the potential will be indicated on the meter.

By operating the TEST REV key you can test the ring side of the line for negative battery.

Bridge Loop. For this test place the selector switch on step 4. Trace the path from the tip conductor of the test jack, through the Wheatstone bridge to the ring conductor of the test jack. This allows you to test for the loop resistance of the line or for a shorted cable pair.

Bridge, Tip, or Ring to Ground. By placing the selector switch on step 5 you can test the line for a ground. With no keys operated you are testing the tip side of the line for ground potential; you test the ring side by operating the TEST REV key. Trace the path for a ground on the tip side of the line under test. Remember that this bridge is set to read a short; and from a grounded line to a ground, with the bridge in the middle, it appears to be a short to the bridge circuit. Here is the path: ground on the tip side of the line; in the tip conductor of the test jack; through contacts of the TEST REV key in the normal position; through the D contact at step 5 of the selector switch to the X-2 terminal post of the bridge; and through the bridge circuit to terminal X-1 to ground on step 5 of the B selector switch contact. With ground present, a reading is obtained; if the tip side is not grounded, no reading is obtained. NOTE: Before testing any circuit with the bridge MAKE SURE NO BATTERY POTENTIAL IS PRESENT. Battery potential will destroy the bridge. To test the ring side of the line for ground, operate the TEST REV key.

Exercises (236):

Identify the actions that occur in the circuits indicated below for the conditions specified.

1. A subscriber complains that his phone is dead. Test results indicate that the line is shorted (foldout 7).
   a. How is a short found using the test board?

   b. What test must be performed prior to the test that found the short? Why?

2. Testing of a PBX switchboard common battery line circuit (foldout 3) from the IN test jack.

a. How, using the test board (foldout 7), do you test for a battery potential on the ring side of the line? What is the path from the test jack through the test desk circuitry?

b. How, using the test board (foldout 7), do you test for a ground potential on the tip side of the line? What is the path from the test jack through the test desk circuitry?

6-6. Power and Ringing Equipment

One of the truly necessary accessories in any

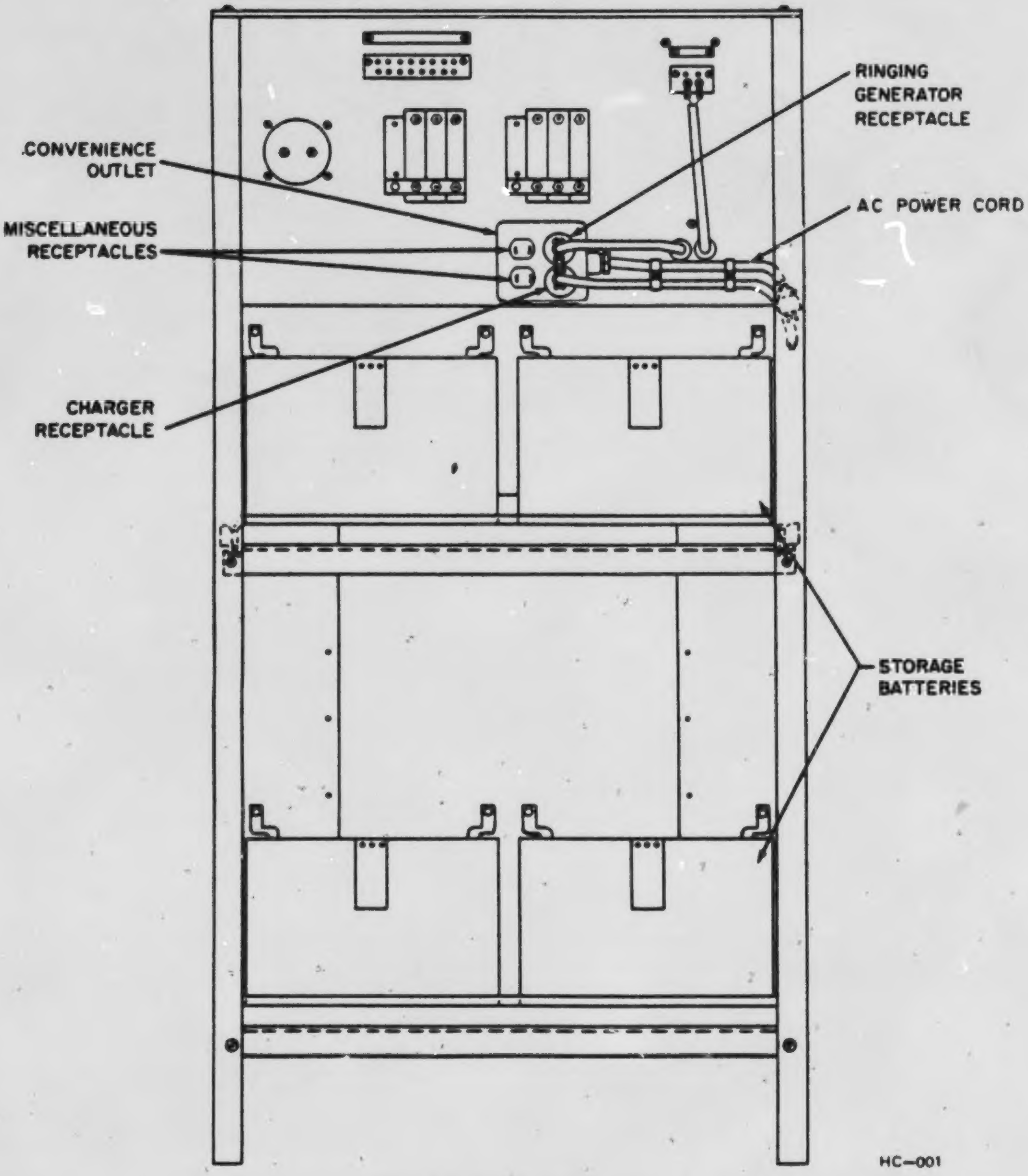

Figure 6-9. Power supply, rear view.

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electromechanical telephone system is a power supply. The manual system we are discussing requires 24 volts DC and 20-hertz ringing current.

237. Use the power and ringing equipment schematic diagrams in this segment to identify circuit actions for specified conditions; and using trouble symptoms, identify the probable cause and state the corrective action.

Components. The power supply face equipment for this manual telephone system contains six circuit breakers, an ammeter, and a voltmeter. There is a designation strip mounted above the circuit breaker switches for identifying the equipment supplied current through each breaker.

The rear of the power supply (fig. 6-9) contains an AC power cord which connects to the 115-volt AC primary power supply and a convenience outlet for interconnecting other items to the AC supply; the ringing generator, for example.

It also contains a constant voltage charger for charging the storage battery, which supplies the 24 volts DC for the system. The battery distribution and fuse alarm circuits are located in both the relay rack and section 2 at the MDF.

Battery Distribution and Fuse Alarm Circuits. Figure 6-10 shows that three of the six circuit breakers are for AC; whereas, the other three are for DC. The leads for the battery distribution circuit connect to DC circuit breakers.

The battery distribution and fuse alarm circuit for magneto and radio lines and the test panel is seen in figure 6-11. The −24V and +GRD leads

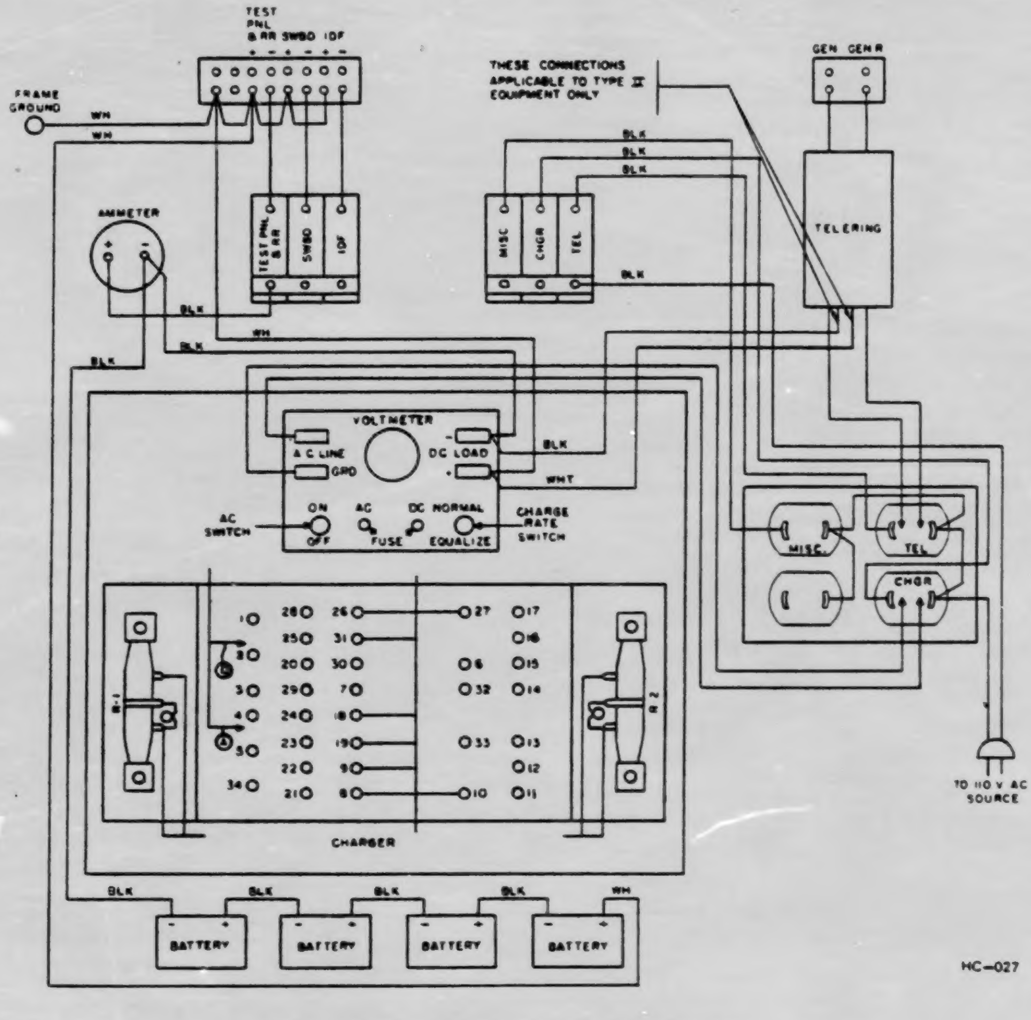


Figure 6-10. Power supply, power and battery connections.

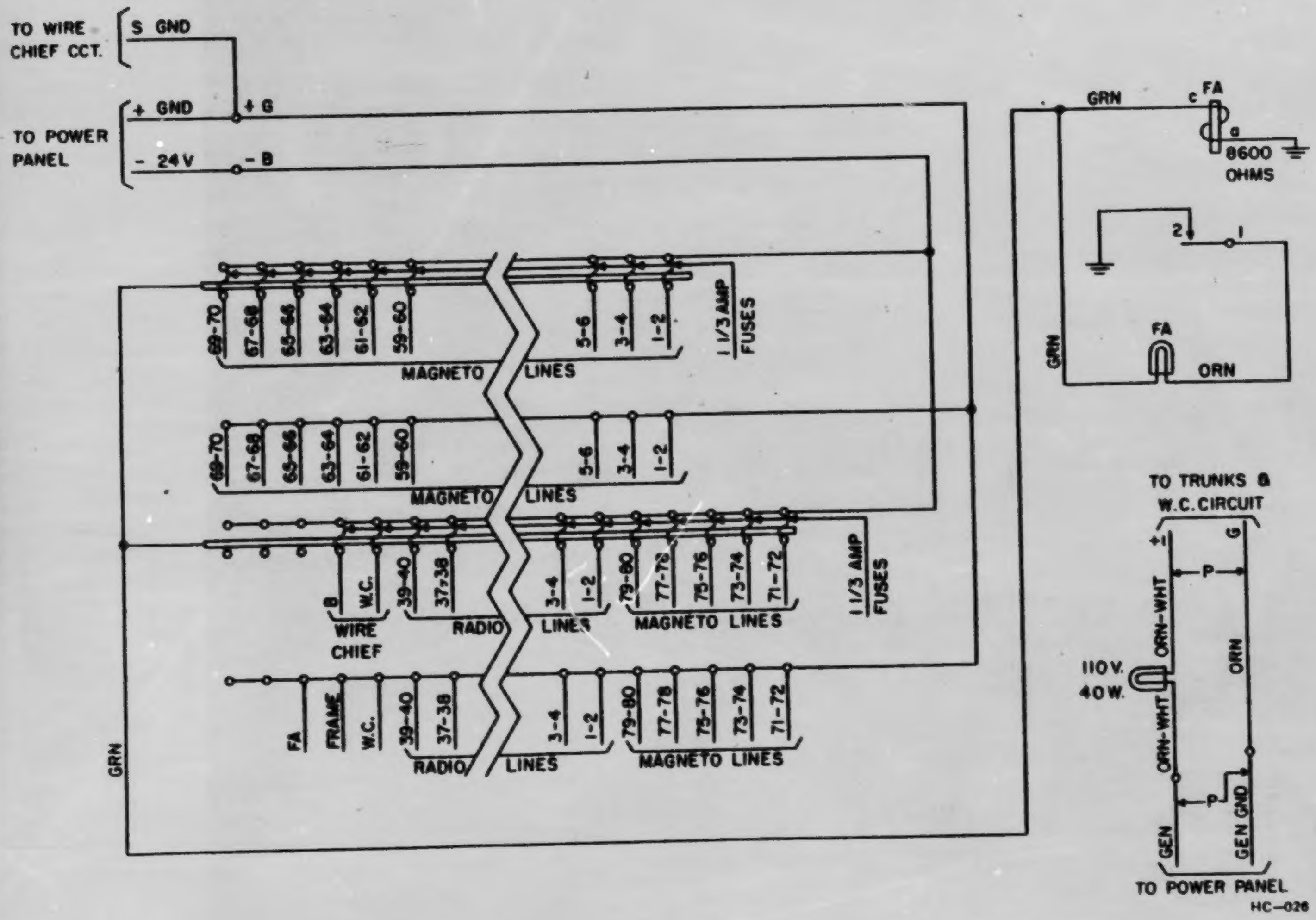


Figure 6-11. Battery distribution and fuse alarm circuit for magneto and radio line circuits.

going to the power panel connect to one of the three DC circuit breakers. This fuse panel is mounted in the back of the test panel which is mounted in the relay rack. The fuses used in these panels are $1\frac{1}{3}$ amp indicator alarm-type fuses like those you saw in the XY telephone exchange in Tech School. You know from the battery distribution circuits in your central office that battery is connected to only one of the two posts that the fuse connects to. You also know that the ring side of a circuit is connected to the other fuse mounting stud and thus to the battery through the fuse. The other side of the circuit is connected directly to ground, not passing through a fuse. The battery and the ground terminations are shown in figure 6-11.

The bar running between the rows of fuse studs is in effect one contact in the path that operates the FA (fuse alarm) relay. When a circuit is overloaded

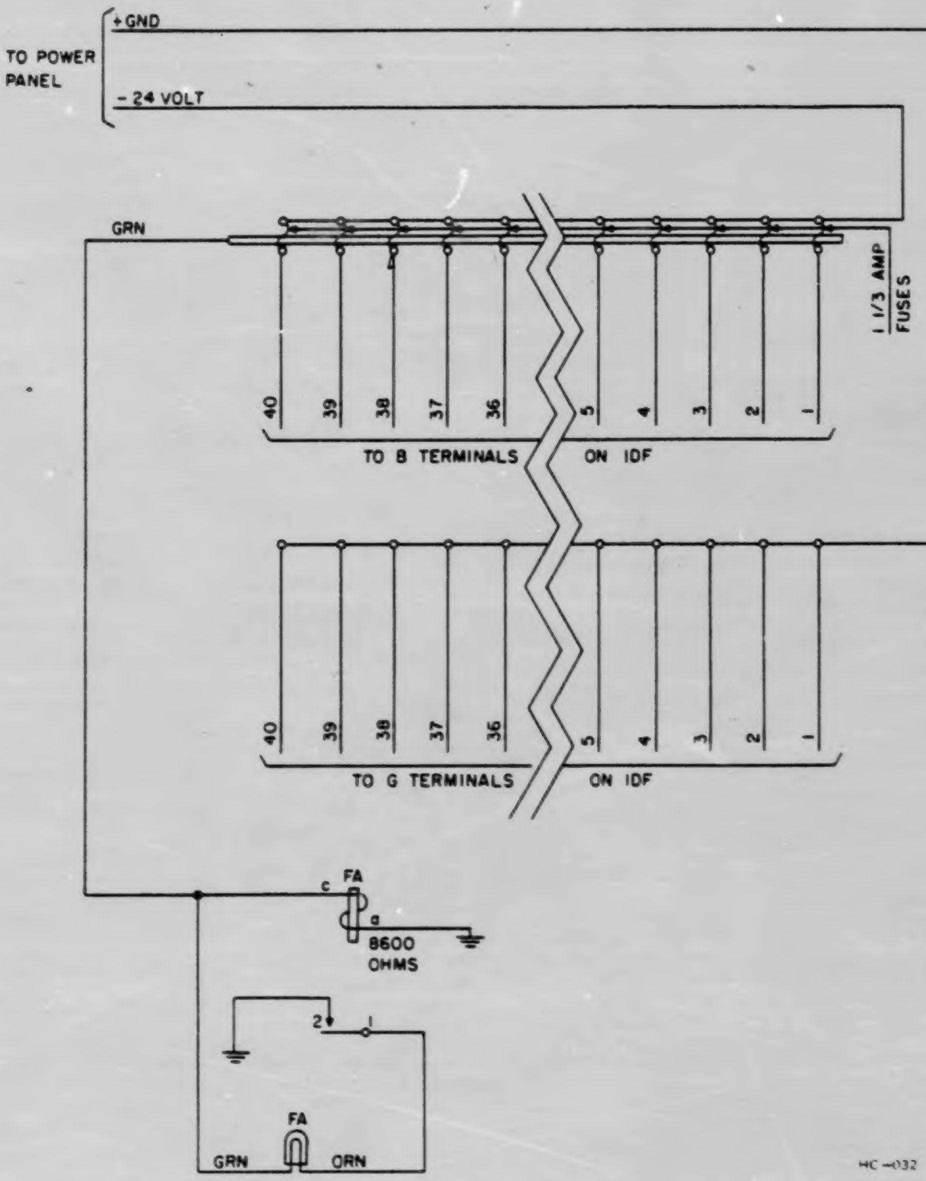


Figure 6-12. Battery distribution and fuse alarm circuit for operator's telephone units (10 line).

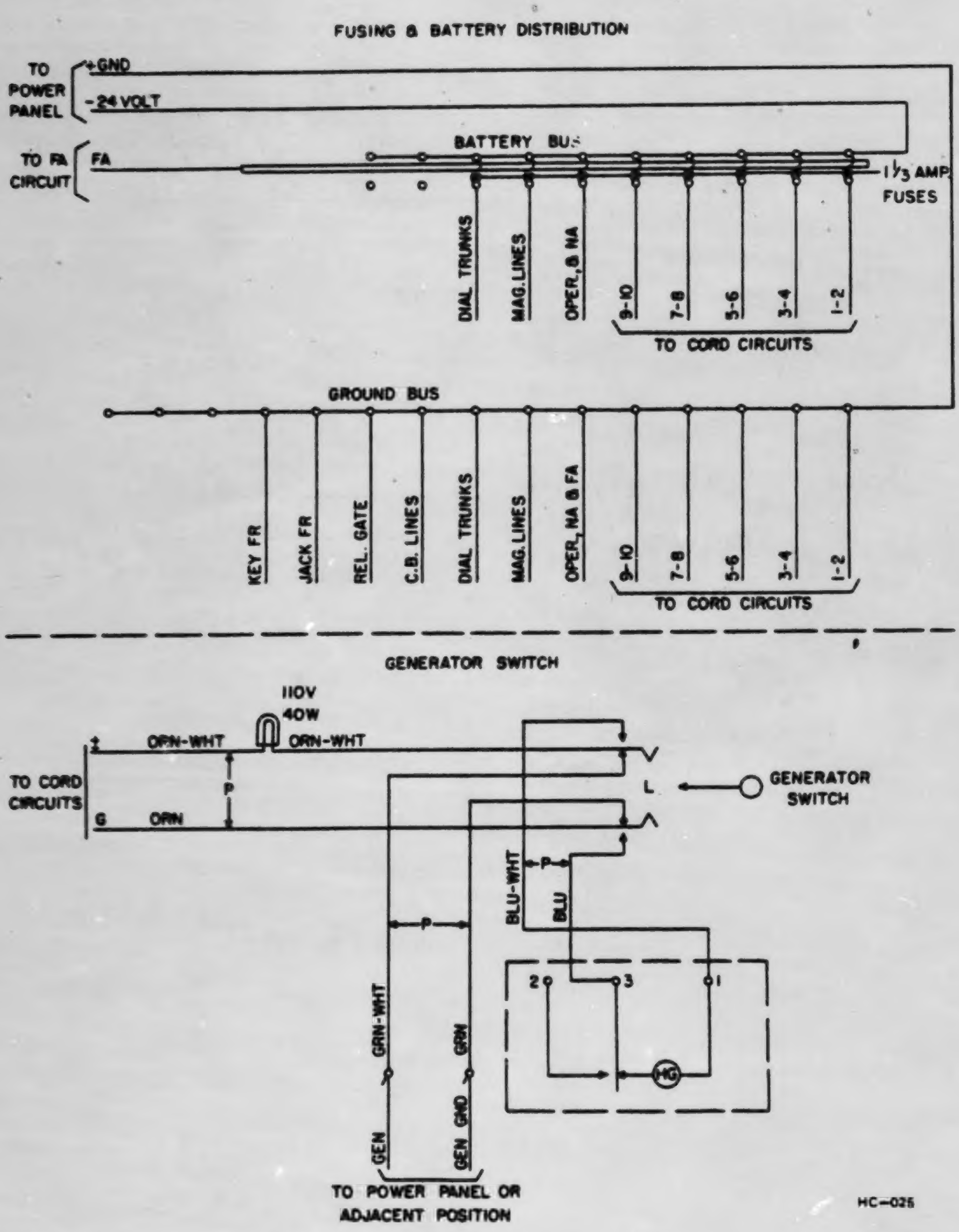


Figure 6-13. PBX switchboard generator and fusing circuit.

and blows its $1\frac{1}{3}$ amp fuse, the wing of the fuse connected to the battery side drops down and makes contact with the center bar; this causes the FA relay to operate. Its 1 and 2 contacts make, lighting the fuse alarm lamp.

Figure 6-12 is the battery distribution and fuse alarm circuit for the operator's telephone units (10 line). It is located on section two of the MDF and is, in operation, identical to the circuit in figure 6-11.

The PBX switchboard generator and fusing circuit (fig. 6-13) and the associated fuse alarm circuit (fig. 6-14) are located on the first position of the PBX switchboard. The fusing and battery distribution (fig. 6-13) and the fuse alarm circuit are very similar to the other figures you have had. This fuse alarm circuit comes equipped with a DC operated bell, controlled by a fuse alarm key. The fuse alarm lamp and key are located on the face equipment of the switchboard. The generator switch allows the operator to transfer, during power failures, the path for ringing generator to the hand

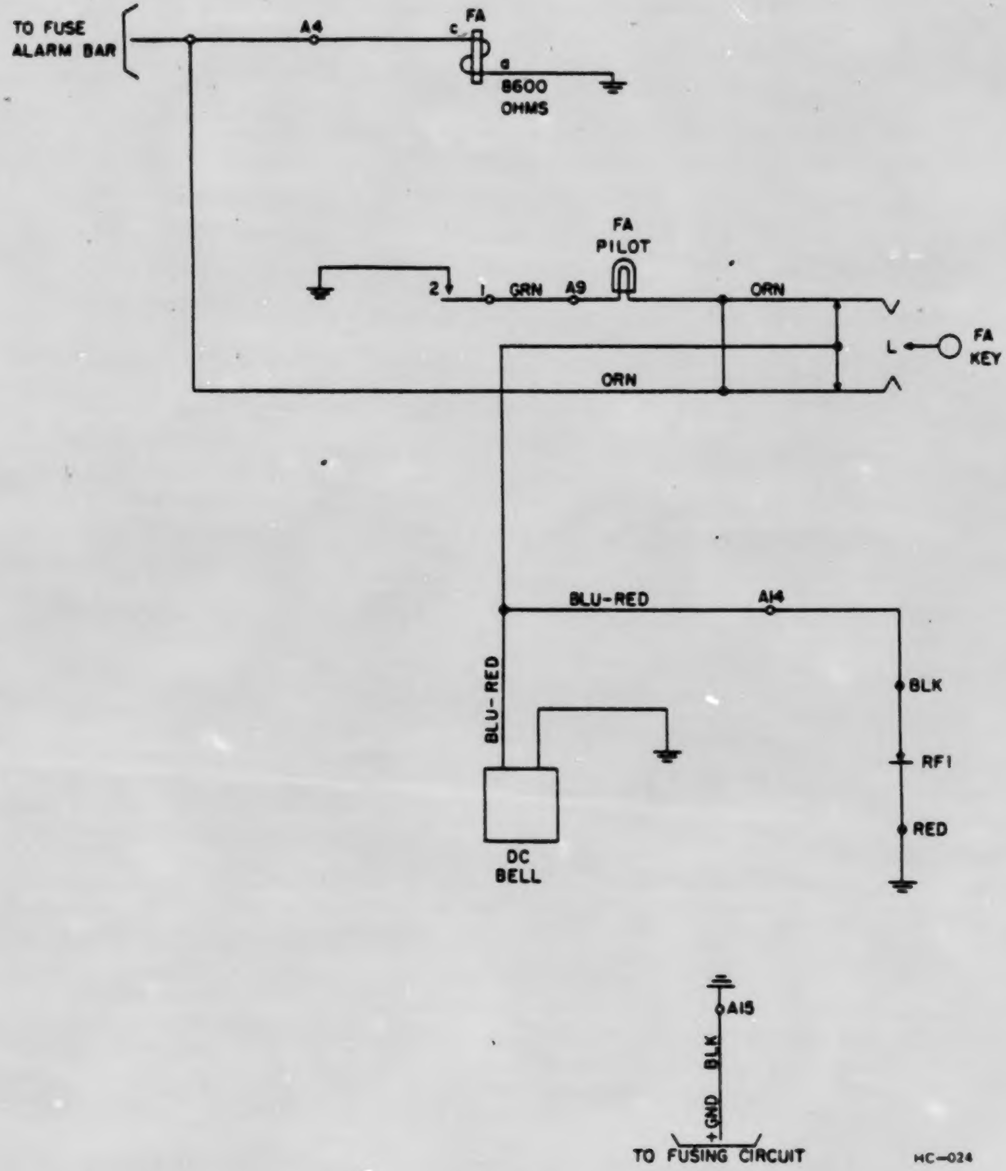


Figure 6-14. PBX switchboard fuse alarm circuit.

generator (HG) on his switchboard position. The switch and lamp for generator are located on the face equipment of the switchboard.

Exercises (237):

Use the figures and information given below to answer the following questions about power and ringing equipment.

1. What happens in the circuit, shown in figure 6-11, when a magneto circuit fuse blows? Why?

2. Why, when the FA relay in figure 6-14 operates, does the bell ring but the lamp not light? What is the corrective action? What type of test will pin it down to one trouble only?

3. Two fuses in the circuit shown in figure 6-12 are blown bringing in an alarm. When the first fuse is removed the fuse alarm lamp goes out. Why?

Manual Central Office Maintenance

THE BACKBONE of good service from a manual telephone system, or any electromechanical telephone system, is a periodic (routine) system of inspections and maintenance.

In this chapter we discuss the preventive maintenance inspection (PMI) system, the use of PMI workcards, the makeup of the distributing frames, and the running of jumpers.

7-1. Preventive Maintenance Inspection System

Tech Order 00-20-1 states, *"All Air Force equipment* must receive repetitive inspections of sufficient thoroughness to verify serviceability or detect deficiencies and malfunctions. These inspections, when combined with effective repair or modification actions, will assure the highest possible degree of support to the mission of each Air Force unit."

What is being said is that a periodic system of inspection and maintenance will be set up to find and fix minor troubles, to prevent major equipment troubles, and circuit outages.

Our mission as switching equipment repairmen is to provide the BEST telephone service humanly possible.

238. Given a list of page and paragraph titles from workcard type tech orders, state the type of information contained under each.

In order to do this job you need some type of guideline to tell you what to do, how to do it, when to do it, what to do it with, and why you are doing it.

You have at your disposal, for your particular telephone system, a workcard type of tech order. For the manual telephone system you are studying, it is TO 31W1-2FTA13-6WC-1. For the XY system, discussed in Volume 4 of this course, it is TO 31W2-4-120-6WC-1. All workcard TOs are identified by the -6WC- identifier at the end of the TO number.

After the A page, in a tech order, the next page (or pages) is the table of contents. The table of contents for -6WC-type tech orders is laid out using the numerical designator of the PMIs as a guide. In other words, 1-1 is the first routine (PMI) listed in the table of contents. Next after the table of contents is an INTRODUCTION page. This page has three sections: *purpose, scope,* and *responsibilities.* This page states the purpose of the workcard set, tells who it applies to, and lists the maintenance supervisor's responsibilities with respect to the use of the workcard set and insuring proper documentation of PMIs.

The next page contains a recommended schedule for the accomplishment of routines. This page is normally broken out by routine number and the type of operation for the exchange—continuous, tactical, or standby. The number of days between inspections is listed under each type of operation.

Next you find a page entitled, "Suggestions for improving the preventive maintenance program." This page contains some good commonsense items such as these: don't be a knob twister; insure that test equipment is properly calibrated; etc.

Next is the information you are really looking for. Each PMI is broken into four major areas. The *General Information* section contains the purpose of the routine, what to do if established results are not met, and the approximate time required to perform the routine.

The *Test Equipment Required* section lists items that are necessary to perform the routine (such as: multimeter, hydrometer, or test set).

The *Materials Required* section lists items needed to perform the routine (such as: lubricants or tools).

The *Procedures* section contains step-by-step instructions for performing the routine, expected test results, and illustrations to clarify instructions.

Exercises (238):

State the type of information contained under each of the following listed titles from workcard type tech orders.

1. Table of contents (page).

2. Introduction (page).

3. General information (paragraph).

4. Materials required (paragraph).

5. Procedures (paragraph).

7-2. PMIs

Now that we have discussed the PMI system and the makeup of the workcard tech orders we need to discuss types of PMIs and locally designed PMIs.

239. State when and why different types of PMIs are performed.

The PMI system is anything but stagnant. Granted, some of the PMIs that you perform in the automatic and manual systems have not changed in years. This means that they are doing the job; not that anybody cares. You care; and if there is a better way to do something you should bring it to someone's attention. There is a method for doing this; but first let us look at the types of PMIs.

Types of PMIs. There are three types of PMIs: types 1, 3, and 2.

Type 1, performance routines. These check the operation of the equipment under nearly normal conditions.They are, as a general rule, performed every 7 to 28 days. These routines help you find most of the troubles that are in your equipment.

Type 3, servicing routines. The purpose of this type is to keep things running clean and smooth. In our business, especially in the automatic exchanges, lubrication is a must. Oil and the like gather dust almost like a magnet; this over a long time leads to a sticky mess that slows or stops mechanical actions instead of helping them. These routines are normally performed every 90 to 180 days. This does not mean that all the two-motion switches in your exchange are cleaned and oiled in one day; just that each switch is done once in the allotted time frame.

Type 2, alignment and adjustment routines. These are no longer a part of the scheduled PMIs. They once were; but it was found that by scheduling this type of PMI, more harm was done than good. You do not wake a sleeping baby to feed him just because his schedule says he is supposed to eat at a certain time.

It has been found that if equipment needs adjustment, this will show up during the performance of type 1 PMIs and sometimes during the performance of type 3 PMIs.

As we have said earlier, PMIs are the backbone of good service and effective maintenance; but what happens when a PMI is not doing the job it should or if a PMI is needed and none exists?

Inspection Workcard, AFTO Form 26D. Tech Order 00-20-1, Chapter 4 states, "Additional inspection requirements that are necessary due to local conditions, such as types of missions, special utilization, or geographic locations, will be entered on locally prepared inspection workcards by authorized individuals as prescribed by the major command and in accordance with TO 00-5-1." The AFTO Form 26D is used for this purpose. It is to be made up in the format of the workcard-type tech orders.

The quality control function in your organization knows how to go about getting this done. Chances are that you will seldom have to develop a PMI; but the PMI is a tool that you use, and the better the tool, the easier the job. Use it to your advantage.

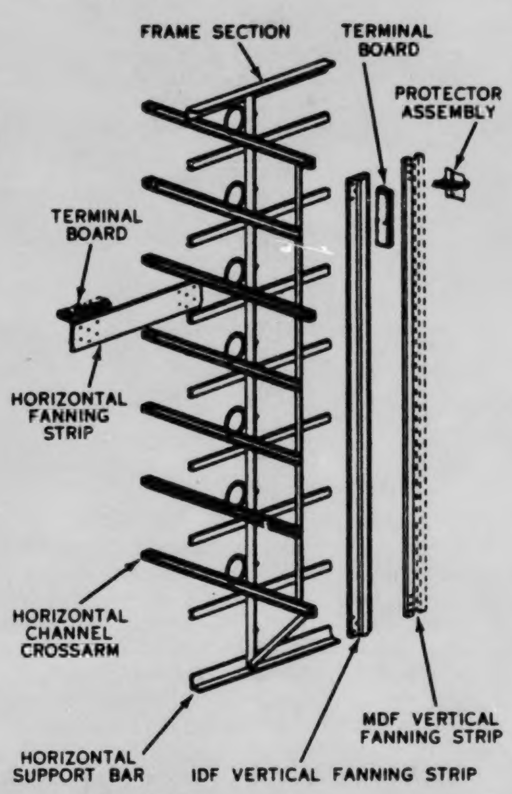


Figure 7-1. Distributing frame components.

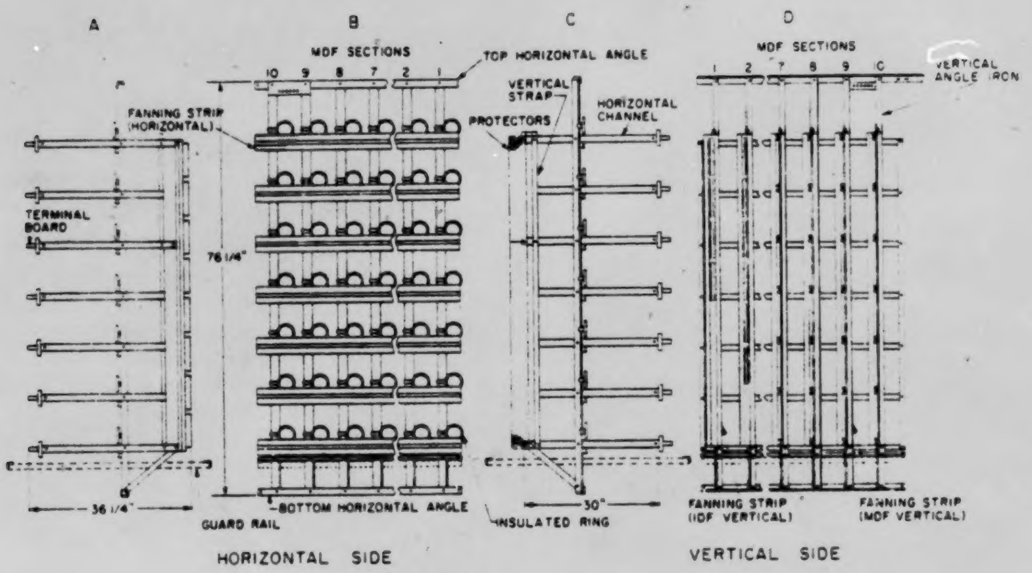


Figure 7-2. Four views of a distributing frame.

Exercises (239):

1. Why are type 1 PMIs performed?

2. When are type 2 PMIs performed?

3. When are types 1 and 3 PMIs performed?

4. Why are type 3 PMIs performed?

7-3. Distributing Frames

The distributing frame provides devices which permit cross-connections between the lines and trunks from the outside equipment and between the switching equipment units within the central office. Also the distributing frame mounts protective devices, serves as a testing point, and permits interconnection between certain equipment units within the central office. The section that terminates the outside lines is often referred to as the main distributing frame (MDF); the interconnecting section is referred to as the intermediate distributing frame (IDF). The practice of placing the two frames together so that they appear as one unit has resulted in the unit's being called the combined distributing frame (CDF). The additional term of trunk intermediate distributing frame (TIDF) may also be used to identify a section of the distributing frame. Included as components of the distributing frame are the channels, support bars, fanning strips, guardrails, terminal boards, insulated rings, and protector assemblies.

240. Given selected distributing frame trouble symptoms, identify the probable causes of trouble and state the corrective action for each.

Channels and Support Bars. Each section of a distributing frame has a vertical angle iron with attached horizontal channels. Figure 7-1 shows a vertical angle iron with seven horizontal channels. There are also nine horizontal support bars spaced along the vertical iron; the top and bottom bars are extra heavy to hold the section in the desired position. There is a strap bolted to the end of the

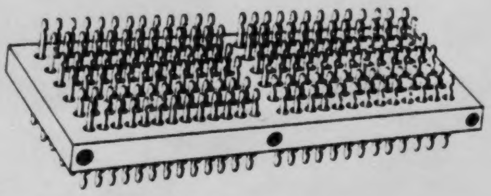


Figure 7-3. Horizontal terminal board.

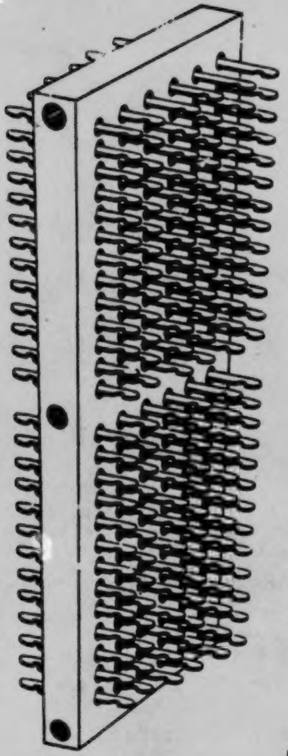


Figure 7-4. Vertical terminal board.

remaining seven support bars to keep them in place, but figure 7-1 does not picture this strap.

Fanning Strips. Three types of fanning strips are used to distribute the conductors to the terminals of the terminal board. In figure 7-1 the IDF vertical fanning strip is T-shaped and extends nearly the full length of the section. The flat portion of this strip has drilled holes for wires to pass through, and the raised portion of the strip mounts the vertical terminal boards.

The MDF's vertical fanning strip is made in two sections, with an iron strap between. The three devices are then bolted together to provide the support and terminations for the protector assemblies.

The fanning strips used on the horizontal side of the MDF extend the full width of the frame. The separated (fanned) conductors are passed through the holes at the top and bottom of the strip, and the centrally mounted horizontal terminal board includes the terminals which terminate these wires. Figure 7-2, part B, shows this horizontal arrangement at the MDF. The first two verticals at the left in part D of figure 7-2 show placement of the components as you would find them on the IDF; and the four verticals to their right illustrate the MDF vertical arrangement, but without any protectors attached.

Guardrails. Part C of figure 7-2 indicates by dashed lines the position of a guardrail. This length of angle iron protects the MDF from damage caused by ladders or other floor equipment. These guardrails are bolted to supports and are junctioned, where necessary, with space plates. End-guard support and end-guards are similarly mounted to protect the ends of the frame and to form a continuous protection. This protection extends slightly beyond the front of the terminal boards and protectors.

Terminal Boards. The terminal board shown in figure 7-3 has 156 terminals. These terminals are placed with three pairs to each row and 26 rows to the board. To facilitate soldering, the rear 52 terminals of the board are equal in length, and they are somewhat longer than the middle 52 terminals.

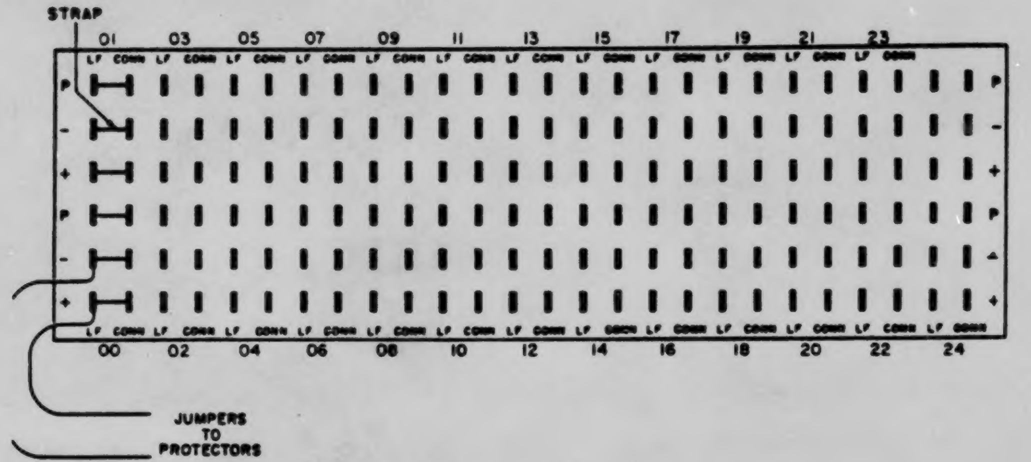


Figure 7-5. Numbering for a horizontal terminal board.

223

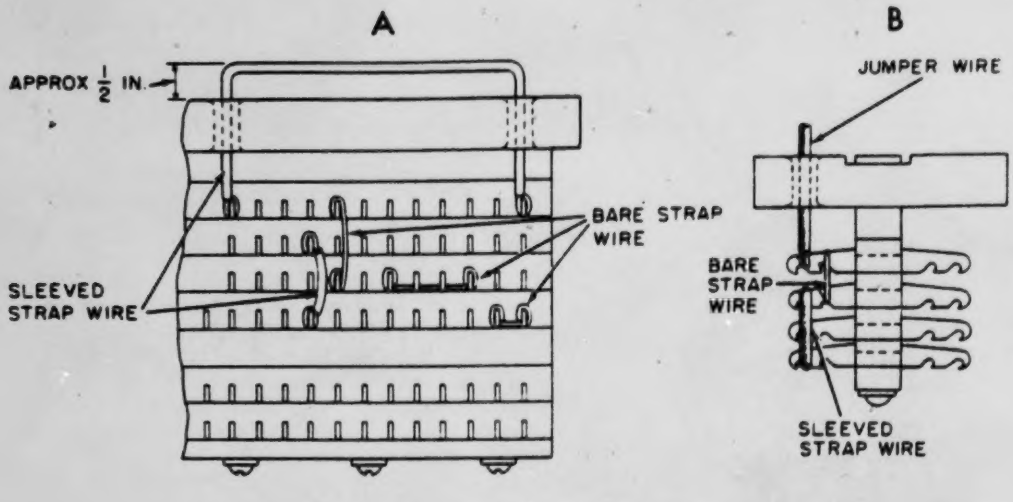


Figure 7-6. Strapping at the distributing frame terminal boards.

The front terminal pairs are the shortest terminals. You can see that each terminal extends beyond the board on two sides, thus permitting several connections to be made. These connections can also be made without piling or bunching of the wires. The terminal board of figure 7-3 is sitting as it would be placed on a horizontal fanning strip. For its placement on a vertical fanning strip, picture it as standing on either of the short ends. Figure 7-4 may help you to understand this vertical position of the board and its terminal arrangement. Figure 7-5 shows the top view of a horizontal terminal board. You can see clearly the 26 rows of terminals with 6 terminals to the row. Notice too, that each row of six terminals has two + terminals, two − terminals, and two C terminals. Remember that the C terminal is identified as S on some terminal boards. Notice also that the rows marked "CONN" are parallel to the rows marked "LF." The first line (00) connects with the six strapped terminals at the left front in figure 7-5 and line 01 terminates at the three rear terminals of rows 1 and 2. This line-connecting arrangement allows for all the odd-numbered lines (01, 03, 05, 07, etc.) at the rear of

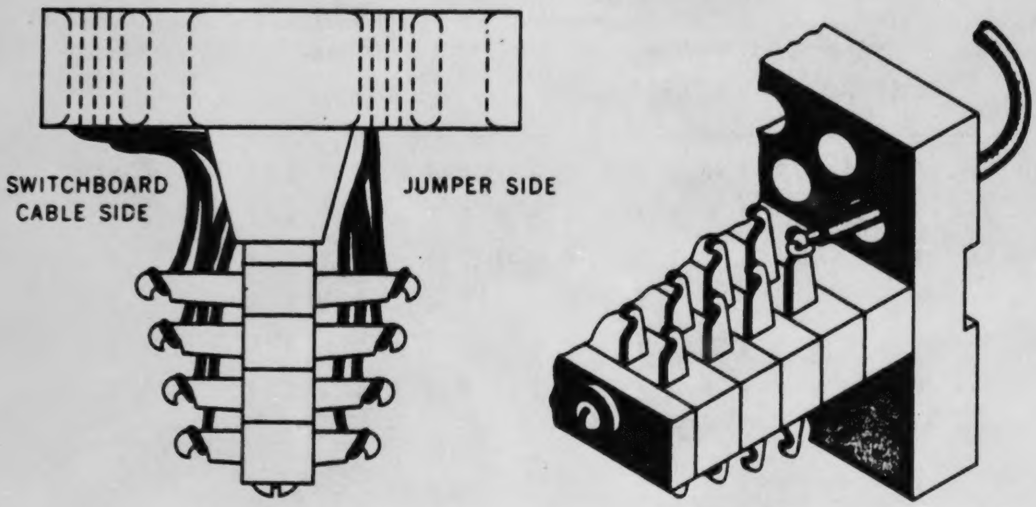


Figure 7-7. Conductor entry into a distributing frame terminal board.

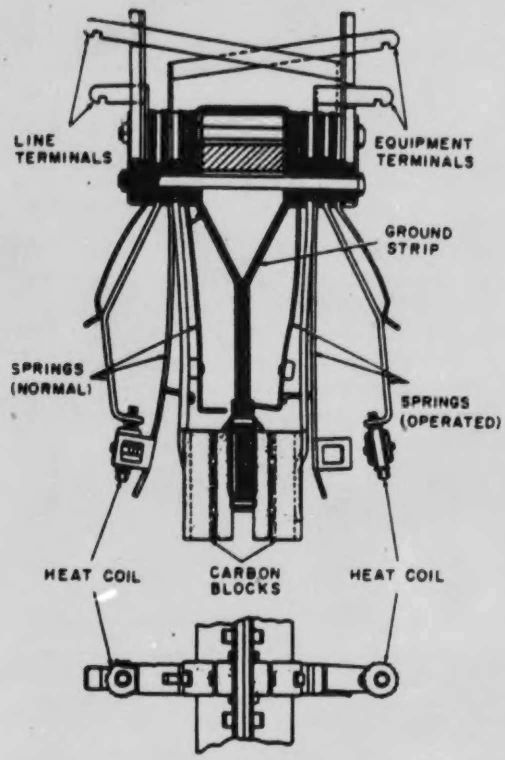


Figure 7-8. Distributing frame protector assembly.

the terminal board and the even-numbered lines at the front of the terminal board. A +, a −, and a C terminal for rows 25 and 26 are vacant on the terminal board we show.

Short, bare wires (straps) are placed from the top of the linefinder (LF) terminal to the top of the connector (CONN) terminal on each of the +, −, and C terminals; figure 7-5 shows only the terminals for lines 00 and 01 so connected. These cross-connections are necessary if the equipment associated with the line used is to be busied to other calls during a conversation. The CONN terminal must be cross-connected to the LF terminal at the MDF if the CO relay of the line equipment is to be able to operate. Figure 7-6 is a partial, simplified illustration showing several methods of making cross-connections at an individual terminal board. The connections shown at figure 7-6, A, are on a horizontal terminal board. The strap at the right front is the LF-CONN terminals cross-connection. Short, bare cross-connecting wires are permissible where there is no danger of short-circuiting to another circuit. Insulated straps (jumpers) have to be used where protection from short circuits is necessary. These LF-CONN terminals, at the underside of the horizontal board, are connected to the cables which come from the linefinder and connector units. Figure 7-6,B. shows how to connect straps at the vertical terminal boards. You can see that two terminals next to each other on this board can also be connected together with a bare wire. B of this figure shows also that separated terminals are connected with an insulated strap. Cable conductors are permanently connected to each notched terminal by skinning, scraping, and soldering. Placement of the conductors conforms to the color code established by the manufacturer. For vertical terminal blocks, the conductor is brought under its associated terminal; the conductor is brought to the left of the associated terminal at a horizontal block. Figure 7-7,A, shows conductors at a vertical block terminal, and 7-7,B, shows a conductor entry and attachment to a horizontal block terminal.

Insulated Rings. For each horizontal at each section, there is a jumper ring. These rings permit the jumper to be changed in direction without damage. These rings are insulated to protect the jumpers from being chafed by any sharp corners of the framework. Figure 7-2,A, B, and C, shows the position of these rings on a frame.

Protector Assembly. The protector assemblies consist of heat coils, carbon blocks, line and equipment terminals, ground strips, and operating springs. Figure 7-8 illustrates these components. The heat coil, one of which is pictured in figure 7-9, is used only at the main distributing frame. A

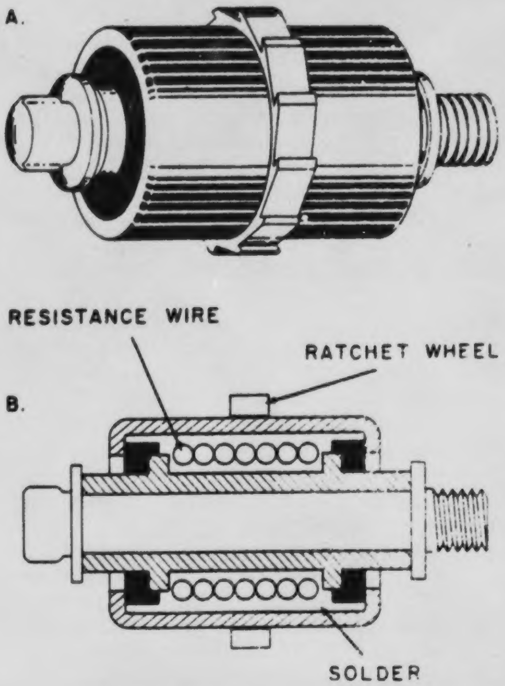


Figure 7-9. Heat coils for telephone circuits.

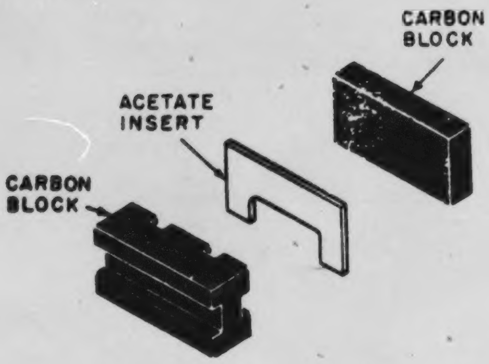


Figure 7-10. Carbon block assembly.

small-value current in the line circuit may overheat the apparatus. Therefore, a heat coil is placed in series with each incoming line conductor to protect against current which results from any accidental contact with power circuits. This sneak current protection is generally required for local circuits rather than for long-distance circuits. A sneak current of 0.35 to 0.45 ampere in the circuit for a period of approximately 3 hours melts the solder (seen in B of figure 7-9) within the coil which, in turn, releases the ratchet wheel. As a result of this action, ground is connected to an alarm circuit and the operating circuit for the incoming lines is opened. A few minutes after the ratchet wheel has rotated and released the alarm spring which grounds the alarm circuit, the solder of the coil will have cooled sufficiently to permit the wheel to support the pressure of the spring again. Thus, this heat coil can be used repeatedly. A current of 0.5 ampere or greater will operate the heat coil immediately.

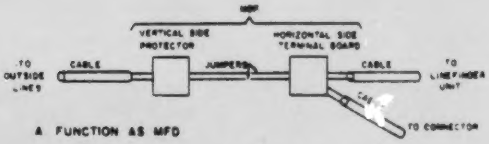
The heat coil at the left in figure 7-8 has not operated; therefore, its associated springs are held out of contact with the ground strip. The heat coil at the right has operated; thus, it has released the spring (with a square-shaped catch), which depresses a second spring. This mate spring is shown against the ground strip. This grounded spring operates an alarm at the power panel.

The carbon blocks (open-space cutout type of protective device) respond to high voltages introduced by the outside lines or trunks. These voltages can be caused by wind blowing a telephone line against a powerline or by lightning. Figure 7-10 pictures the construction of a carbon block assembly. The carbon blocks are separated by a thin 0.005-inch strip of mica which is partially cut away in the center. One carbon block of the assembly connects to the line and the second block connects to ground. A surge of high voltage will arc across the airgap between the blocks and discharge to ground. If the high voltage is continuously connected to the line, the carbon blocks break down and ground the circuit permanently. When this collapse occurs, you must replace the destroyed carbon block assembly with a new one in order to make this line effective again. Remember that the protector assembly of figure 7-8 protects only one cable pair.

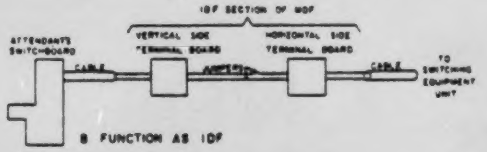
Exercises (240):

Identify the probable cause and state the corrective action for each distributing frame trouble described below.

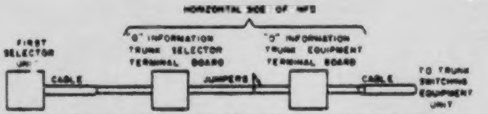
1. The line relay has a shorted winding and when the subscriber goes off hook the circuit pulls .57 ampere before dial tone is received and the subscriber dials the desired number.



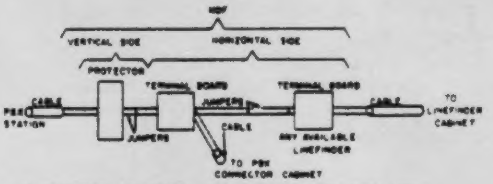
A FUNCTION AS MFD



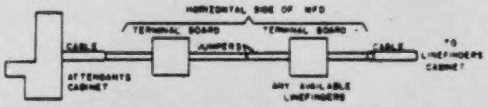
B FUNCTION AS IDF



C FUNCTION AS SPECIAL IDF BETWEEN SELECTOR AND TRUNK SWITCHING EQUIPMENT UNITS



D. FUNCTION AS SPECIAL IDF BETWEEN PBX LINES AND LINEFINDERS



E. FUNCTION AS SPECIAL IDF BETWEEN EQUIPMENT FOR OUT-DIAL TRUNKS TO LINEFINDERS AND LINEFINDERS CABINET

Figure 7-11. Block diagram showing distributing frame functions.

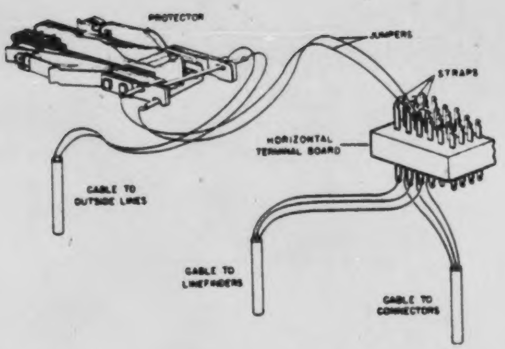


Figure 7-12. Connecting jumpers from protector assembly to horizontal terminal board.

2. Subscriber A initiates a call, during conversation someone that called subscriber A breaks into the conversation.

3. Subscriber B can make, but not receive, calls.

4. A subscriber's line relay is operated and the phone is on the hook. When tested from the test board a ground is seen on the ring side of the line, but the cable pair is not grounded.

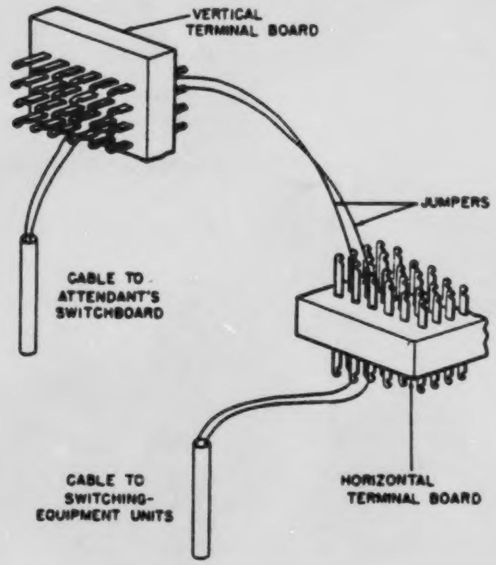

VERTICAL TERMINAL BOARD
JUMPERS
CABLE TO ATTENDANT'S SWITCHBOARD
CABLE TO SWITCHING-EQUIPMENT UNITS
HORIZONTAL TERMINAL BOARD

Figure 7-13. Vertical terminal board to horizontal terminal board jumpers.

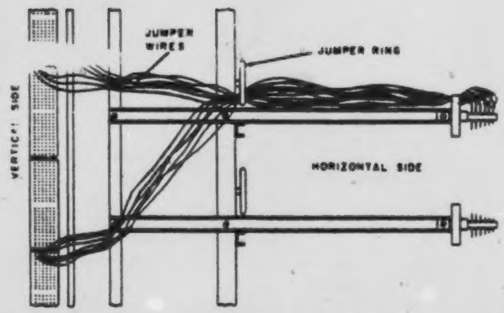


Figure 7-14. Jumpering from MDF vertical to MDF horizontal board.

7-4. Cross-Connecting the Distributing Frame

The MDF provides the terminations for all pairs within the incoming telephone cables. These cables contain paper-insulated wires which are connected to the line terminals at the protector assembly. The IDF provides terminations for interoffice trunking allowing for the flexibility desired to meet changing needs. In this section, we discuss distributing frames for both manual and automatic telephone systems.

241. State the type and location of cross-connects used for various equipment arrangements.

Look at figure 7-8 to see the line and equipment terminals for the protector assembly. The first pair is connected to the top protector, the second pair terminates at the protector directly below the top protector, and the third pair attaches to the protector below the second protector. Thus, you can see that the line-connecting pattern to the protectors is from the top of the MDF's vertical to the bottom.

The equipment terminals of the protector assembly are cross-connected (jumpered) to the terminals on the top side of the terminal boards at the horizontal of the MDF. The lower terminals of these same horizontal boards terminate pairs of cables from the line equipment relays and switching equipment. Detail A of figure 7-11 is one method of showing the distributing frame's division, and figure 7-12 shows the connections.

Circuits from the attendant switchboard and test desk connect at the vertical sections also. But, these terminations are at the terminal boards of the IDF. You should remember that included on IDF sections are the wires for the trunks; out-dial to connector; and out-dial to linefinder, information, city, magneto, common-battery, and PBX connector. The cables from the attendant's cabinet are brought into the left terminal of the terminal board. Again, jumpers tie together these

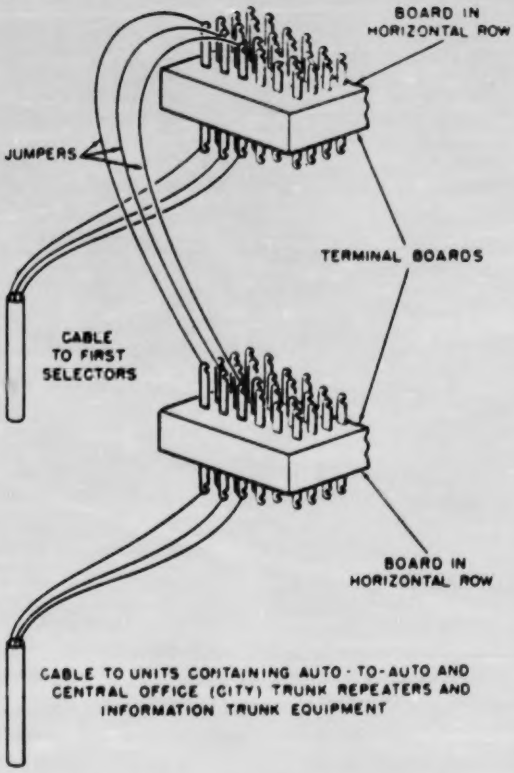

BOARD IN
HORIZONTAL ROW
JUMPERS
TERMINAL BOARDS
CABLE
TO FIRST
SELECTORS
BOARD IN
HORIZONTAL ROW
CABLE TO UNITS CONTAINING AUTO-TO-AUTO AND
CENTRAL OFFICE (CITY) TRUNK REPEATERS AND
INFORMATION TRUNK EQUIPMENT

Figure 7-15. First selector connections to horizontal terminal boards.

vertical section terminal boards and the horizontal terminal boards. These jumpers connect to the right terminals of the vertical board and the top terminals of the horizontal terminal board. Figure 7-13 reveals these connections and figure 7-14 presents jumpers as they extend from the vertical to a horizontal through the jumper ring. The bottom ends of the horizontal board's terminals connect the cable pairs from the switching equipment units. Illustration B of figure 7-11 presents the plan for connecting the attendant's switchboard.

Future expansion of the central office is to be expected. Some interconnections, therefore, must be of a temporary type. These connections are conveniently made with jumpers which connect between the desired terminals of the horizontal terminal boards. Cables from first selector units are connected to terminals at the underside of the horizontal terminal boards, and jumpers are used to connect these terminals to their associate terminal boards. Figure 7-15 shows these jumpers attached to the terminals at the top of each terminal board. This interconnection between horizontal terminal boards permits one first selector to access 10 specific trunks. For example, dialing the digit 9 progresses the call from the first selector to 1 of 10 city trunks. Figure 7-11,D, illustrates another connection at the distributing frame which provides a special function. The cable from the private branch exchange terminates at the protectors. The jumpers from this vertical extend to a terminal board in the horizontal row. Then this horizontal terminal board is interconnected to a second horizontal terminal board that has access to linefinders. Figure 7-16 pictures the jumpers between the protector and terminal board and those between the two horizontal terminal boards. Again, you can see that the cables terminate at the underside of the horizontal terminal boards.

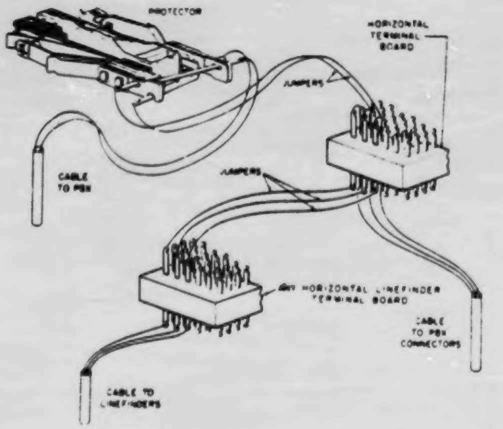


Figure 7-16. Distributing frame jumpering.

Exercises (241):

1. State how the city trunks terminate to the banks of the first selector.

2. State how the line equipment is terminated to the subscriber's line.

3. What do the bottom terminals and left-hand side terminals on the horizontal and vertical terminal blocks of an IDF have in common?

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

200 - 1. A. Spring Assembly. The springs, when operated by the movement of the armature lever arm, make and break electrical circuits.

B. Heelpiece. The heelpiece serves as a mounting for the relay parts. It also confines the magnetic field by reducing reluctance.

C. Armature Yoke. The armature yoke mounts the armature to the heelpiece.

D. Pivot Pin. This allows the armature to swing or pivot to the coil core.

E. Airline or Air Gap. The airline or airgap is a space between the armature and the heelpiece. This space prevents the armature from binding on the heelpiece.

F. Residual Screw. The residual screw is made of brass and extends through the armature. It keeps the armature from touching the core, thus preventing the relay from remaining operated due to residual magnetism after the current has been removed.

G. Armature. The armature movement forces the contact bumper or pushers an adequate distance to make or break all contacts.

H. Coil. The coil is a length of wire wound around a metal case. When current is applied to the coil the core becomes an electromagnet which attracts the armature to it.

I. Armature Lever Arm. The armature lever arm moves to cause the springs of the pileup to make and break electrical circuits.

J. Armature Lever Arm Backstop. This stops the action of the armature lever arm as the relay releases.

K. Copper Slug. A copper slug placed on the armature end of the relay makes it slow to operate. If the copper slug is placed on the opposite end or the heel end makes it slow to release.

L. Terminals. These terminals provide a point to connect negative battery and ground to operate the relay.

M. Armature Yoke Screw. The armature yoke screw secures the armature yoke to the heelpiece. It also controls the amount of airline.

201 - 1. 1,300 ohms.

201 - 2. 3 thousandths of an inch.

201 - 3. Operate - 410 ohms and 96 milliamps.
Nonoperate - 610 ohms and 68 milliamps.

201 - 4. A gauge of 17 thousandths inserted between the residual screw and coil core should definitely allow contacts 4 and 5 of relay B to make when the relay operates.

201 - 5. The positive lead from the current flow test set should be connected to VON spring 4 when adjusting or testing the E relay.

202 - 1. The tools required to adjust the airline are an offset screwdriver and feeler gauges.

202 - 2. The tools required to adjust the residual screw are a small wrench, small screwdriver, and feeler gauge. The test equipment required is a current flow test set.

202 - 3. To make the stroke adjustment the backstop bender, feeler gauge and current flow test set are required.

202 - 4. To make the contact spring adjustments an armature bender for contacts 1 and 2 and a spring bender for contacts 3 and above is needed, as well as the current flow test set.

202 - 5. Operate/Nonoperate requirements are met by using a spring bender and a current flow test set.

203 - 1. The armature arm needs to be adjusted. Feeler gauges, armature bender, and a current flow test are required to make the adjustment. The spring contact adjustments need to be remade and require feeler gauges, spring benders, and a current flow test set to make. The operate/nonoperate values need checking and the stroke setting needs to be reset. Spring benders and the current flow test are required for operate/nonoperate values to be met and a backstop bender and feeler gauges are needed for the stroke setting.

203 - 2. The airline is set too tight (close). A feeler gauge, offset screwdriver, and a current flow test set are required to make the adjustment. From there all adjustments need rechecking and adjusting as outlined in the above answer.

203 - 3. The residual screw adjustment is set short of specifications and the armature is too close to the coil core when operated. A feeler gauge, wrench, screwdriver, and a current flow test set are required to make the adjustment. NOTE: This same trouble symptom could end up being a dirty coil core and not an out of adjustment residual screw. Once the residual screw is properly set, the armature arm must be readjusted using the armature bender. Spring control adjustments and tension must be reset using feeler gauges and the current flow test set. The stroke setting then needs to be made with a backstop bender and a feeler gauge.

204 - 1. 17 is the coil mounting stud nut and washer.
204 - 2. 13 is the mounting plate screw.
204 - 3. 6 is the armature support plate.
204 - 4. 5 is the armature support plate mounting screw.
204 - 5. 15 is the mounting plate.
204 - 6. 14 is the clamping plate.
204 - 7. 1 is the relay coil.

204 - 8. 16 is the relay frame.

204 - 9. 3 is the armature residual plate.

205 - 1. A combination makes-make, under TEST, at 10 thousandths of an inch.

205 - 2. The residual setting of the XD relay in circuit AS-30236 is 4 thousandths of an inch.

205 - 3. The operate value is 19 milliamps and the nonoperate value is 16 milliamps when adjusting the SW relay in circuit AS-30236.

205 - 4. B combination breaks-break, under READJUST, at 18 thousandths of an inch.

206 - 1. To make the residual screw adjustment requires a feeler gauge, wrench, and a screwdriver.

206 - 2. To make the backstop adjustment requires the use of the backstop adjuster tool and a feeler gauge.

206 - 3. To make the spring tension adjustment on break springs requires the use of a spring bender and a pressure gauge.

206 - 4. The make or break adjustment of spring contacts requires the use of feeler gauges, a current flow test set, and a spring bender.

206 - 5. To make the operate or nonoperate value adjustments requires the use of a spring bender and a current flow test set.

207 - 1. The armature support plate needs to be readjusted; this adjustment should not affect the residual screw adjustment but will affect the backstop setting.

207 - 2. The indication here is that spring tension needs to be lessened.

207 - 3. There are two possibilities; first of all the armature support plate probably needs adjustment, but check the backstop setting first.

CHAPTER 2

208 - 1. Vertical interrupter. It works in conjunction with the vertical magnets to control automatic vertical stepping of a linefinder.

208 - 2. Release armature pin. Its function is to move the double detent away from the shaft so the switch can release and cause the double detent to be engaged by the release link at the same time.

208 - 3. Vertical magnet coil. This works with the other vertical magnet coil to pull the vertical armature up when they are energized, to raise the switch shaft.

208 - 4. Shaft spring (helical). The function of the shaft spring is to return the shaft completely to the left (counterclockwise) when the switch releases.

208 - 5. Double detent (dog). The double dog has two functions: (1) to support the shaft during vertical stepping and (2) to prevent the shaft from returning to rotary normal during rotary stepping and conversation.

208 - 6. Stationary detent (dog). It supports the shaft during rotary stepping.

208 - 7. Vertical off-normal (VON) contact assembly. It makes and/or opens circuit paths during the first vertical step (release magnet circuit among others) and just before the shaft returns to vertical normal.

208 - 8. Rotary armature. It moves toward the rotary magnets when they energize, causing the pawl attached to it to step the switch rotary.

208 - 9. Vertical pawl. Its function is to raise the switch shaft when the vertical armature pulls up to the vertical magnet.

209 - 1. The release armature pin needs to be adjusted in toward the double dog. This adjustment requires the use of a wrench and feeler gages.

209 - 2. Chances are the shaft spring needs more tension, but it could be a bad wiper or a wiper that is out of adjustment and dragging on the bank contacts. No tools are required to tension the shaft spring.

209 - 3. The cam needs to be adjusted so that it operates the cam spring assembly between the 10th and 11th rotary steps. A screwdriver is required to make this adjustment.

209 - 4. This trouble could either be vertical magnets out of adjustment, thereby throwing the shaft more steps vertically than it was supposed to go; or the lower arm of the stationary detent is out of adjustment and the pawl strikes the vertical ratchet in the wrong spot. Adjusting the vertical magnets requires the use of wrenches and feeler gauges. Adjusting the stationary dog requires the use of the double dog bender.

209 - 5. The off-normal lever is out of adjustment so that the VONs are not at normal when the switch is at normal. A pair of pliers is needed to adjust the off-normal lever.

210 - 1. Raising the upper dog on the stationary detent raises the shaft during rotary stepping and conversation. This affects the adjustment of the wipers. It could conceivably affect the normal post contact assembly in linefinders and selectors.

210 - 2. Lowering the pawl guide could cause the vertical pawl to raise the shaft more than one step at a time or even possibly cause the vertical pawl to break.

210 - 3. This affects the operation of the VONs. It could cause the release magnet to remain operated continuously and mark the switch busy.

210 - 4. If the pin is screwed out too far, the switch may not release or the double dog may not engage the release link during release.

210 - 5. Lowering the vertical magnets affects the adjustment of the double dog and stationary dog. It also affects the wiper and normal post contact assembly adjustments.

210 - 6. Moving the rotary magnets toward the rear of the switch increases the travel of the armature and pawl. This could lead to more than one rotary step per armature operation.

211 - 1. This is the lock spring. It secures the switch in the switch cell or test set.

211 - 2. Digit drum. It indicates how many steps the switch has taken in the Y direction.

211 - 3. Y magnet assembly. This causes the switch to step in the Y direction when operated.

211 - 4. Guide rule. It indicates how many steps the switch has taken in the X direction.

211 - 5. X armature backstop. It prevents the X magnet armature from being too far from the X magnet.

211 - 6. Release magnet assembly. Causes the switch to release and activates the Z release springs.

211 - 7. Tubular shaft assembly. Its function is to provide the cog roller something to slide and roll on.

211 - 8. X magnet assembly. It causes the cog roller and wiper assembly to move in the X direction when operated.

212 - 1. The X magnet needs to be adjusted so the end of the armature engages the X sprocket and prevents the switch from overstepping in the X direction. A screwdriver and XY switch test set are required for this adjustment.

212 - 2. The Y stop needs to be adjusted. A screwdriver, wrench, and XY switch test set are required to make this adjustment.

212 - 3. The digit drum needs adjustment. An Allen wrench

and feeler gauges are required to make this adjustment

212 - 4. The X backstop needs to be adjusted. This adjustment is made with a screwdriver.

212 - 5. The Y magnet interrupter contacts are not breaking when the magnet operates. Either bumper pliers or a screwdriver, feeler gauges, and an X-Y switch test set are needed to make this adjustment.

213 - 1. Moving the Y retaining pawl assembly forward increases the tangential clearance between the pawl and the cog roller; it also changes the radial clearance between the Y retaining pawl and the tooth of the cog roller. It affects the wipers, as they will stop short of where they should in the wire banks. The adjustment between the Y retaining pawl and the release armature extension arm is also changed.

213 - 2. The X retaining pawl moved to the left causes the cog roller home position to be moved to the left; this affects the X gear cluster (index hole) which in turn affects the X magnet, ejector strap, X-XX tool, switching lever and pinion gear (wipers) adjustments.

213 - 3. Moving the release magnet slightly counterclockwise affects the radial clearance between the Y retaining pawl and the cog roller tooth and might cause the switch to release X first or before Y release is completed.

213 - 4. Turning the stop screw one-half turn counterclockwise decreases the tangential clearance between the Y retaining pawl and the cog roller teeth. It also affects the Y-off-normal (YON) and Y overflow cam adjustment. The pinion gear and digit drum adjustments are also affected as well as cog roller play.

213 - 5. Tightening the front screw of the cog roller support raises the portion of it through which the cog roller passes.

CHAPTER 3

214 - 1. Sound is the sensation caused in the nervous system by vibration of the delicate membranes of the ear.

214 - 2. Sound results from the rapid vibration of a rigid or semirigid body.

214 - 3. Three mediums for sound are air, a liquid, or a solid.

214 - 4. A medium is that which transfers the energy from the vibrating body to some other place, either near or distant. Something (air, a liquid, or a solid) becomes a medium for sound when it absorbs some of the energy from a vibrating body and transfers those vibrations to some other place.

214 - 5. Sound travels through air in the form of condensations and rarefactions.

214 - 6. Condensation is the bunching-up or condensing of air particles on one side of a vibrating body. Rarefaction is the dispersion or thinning out of air particles on the opposite side of the vibrating body.

214 - 7. The representation of a pure tone sound wave on a graph resembles a sine wave.

214 - 8. The frequency, period, and amplitude values of a sound wave can be determined from a graph of that sound wave.

214 - 9. The two major parts of a transmitter are the diaphragm and carbon pocket.

214 - 10. The basic function of a telephone transmitter is to convert the sound waves striking its diaphragm into electrical waves that are identical to those sound waves.

214 - 11. When the carbon granules in the carbon pocket of the transmitter are packed closely together, the resistance in the circuit decreases and the current increases.

214 - 12. They should be identical. This is because the diaphragm of the transmitter vibrates in response to the sound wave; which causes the carbon granules in the carbon pocket to be packed or loosened in response to the diaphragm's vibrations. The resulting current variations should resemble, identically, the sound wave.

214 - 13. The three basic parts of a telephone receiver are a thin metal diaphragm, a permanent magnet, and a coil.

214 - 14. The magnet in the receiver creates a magnetic field that varies (increases or decreases) in strength in step with the varying current in the coil wound around the magnet. The variation in the strength of the magnetic field causes the metal diaphragm to vibrate in response. The vibration of a rigid or semirigid body, such as a thin metal diaphragm, produces a sound wave.

214 - 15. The frequency and waveshape of the electrical signal on the transmission line and the resulting sound wave at the receiver should be identical. This is because the current variations cause a variation in the strength of the magnet's magnetic field; which in turn causes the diaphragm of the receiver to vibrate in response to those changes.

215 - 1. When a common battery subscriber in a manual system lifts his handset from the cradle, it lights a line lamp on the switchboard. The subscriber in an automatic system that goes off-hook starts the linefinder equipment hunting for his bank appearance; and eventually gets dial tone from the first selector. Automatic exchanges have a limited number of common battery (CB) tracks; when a CB subscriber, in an automatic system goes off-hook it lights a line lamp on the attendant's cabinet.

215 - 2. The stepping of selector and connector equipment in response to dial pulses is equivalent to an operator in a manual system looking for the jack of the party requested by the calling party.

215 - 3. The testing of the line, by the connector switch, to determine its condition (idle or busy) is equivalent to the operator in a manual system testing the jack appearance with the call card to determine if the called line is busy.

215 - 4. The subscriber reringing the operator is equivalent to a subscriber in an automatic system hanging up the phone to release the equipment.

CHAPTER 4

216 - 1. The main parts of a C-E scheme are TAB A and TAB B.

216 - 2. Scheme Cover, General Information, and Consolidated List of Materials.

216 - 3. Implementation and Installation or Removal Instructions in SOW format. Also, drawings and applicable support documents.

216 - 4. The scheme is to be performed at Hensley AFB.

216 - 5. The directory numbers will consist of five digits.

216 - 6. Zero will be dialed for information, 9 will be dialed for access to city trunks, 117 will be dialed to contact the fire department, and 118 will be dialed to access the test desk.

217 - 1. Schemes should be inspected prior to the start of work to avoid having to undo work, already done, because some other agency did not accomplish what it should have, or because something that will affect the installation was not considered or known when the scheme was being planned.

217 - 2. Coordinating with agencies at the installation site about requirements such as lighting, power, plumbing, etc., that may affect job progress is the best method along with inspecting the facility against the drawings.

218 - 1. Where floor markers exist, reference lines are established to intersect at right angles at the point where the markers are located.

218 - 2. Where floor markers do not exist, reference lines are established by either the level and square or plumb bob method.

219 - 1.
- a. Place the floor angle on the floor and line it up on the vertical face lines and mark the floor at the mounting holes.
- b. Drill the holes in the floor at the marked places using an electric drill or a star drill and hammer. If the hole is greater than 3/8 inch in diameter drill a pilot hole. The hole will be drilled 1/4 inch deeper than the size of the fastening device.
- c. Clean out the concrete dust during and after drilling the holes.
- d. Insert the fastening devices into the holes.
- e. Place the floor angles on the vertical face lines and fasten loosely in position until the entire line has been laid out.
- f. Check for alignment and levelness; cutting out as much linoleum as necessary under the floor angle to level off the high spots; and light metal shims, the width of the floor angles and at least 4 inches long, at low level areas.
- g. Tighten the mounting fasteners maintaining alignment and levelness.

219 - 2. The hardware required to clamp a small cable rack to a larger one is a side bar and corner clamps.

219 - 3. Cable rack comes in standard 5 and 10 foot lengths.

219 - 4. Cable rack comes in standard widths of 6, 9, 12, 18, and 22 inches.

220 - 1. You should first select cable rack of the proper width in the most economical lengths available. Six 10-foot lengths and a 5 foot length of cable rack, if available, is the best choice.

220 - 2. The second step is placing the first section on the channel bracing above one of the selector bays and secure it with J bolts.

220 - 3. After the first section is secured, connect the next length of cable rack to the end of the first using straight clamps and secure it to the channel bracing with J bolts. This continues until all the cable rack sections above the two selector bays is up and secured.

220 - 4. The placement and securing of cable rack above bays 103 and 104 is done in the same way as above bays 101 and 102.

220 - 5. Once the cable rack runs above the four selector bays is complete, the distance across the aisle, between the two runs must be measured and the last length of cable rack cut to that size. It is connected to the two cable rack runs at the proper end and secured with corner clamps. Then the runs and the crossover length of cable rack must be leveled and completely secured.

221 - 1. The power and ground return cables are placed on the cable rack first; the lengths of switchboard cable are run next; and then the small wires are run.

221 - 2. Two methods of running power cables are directly on top of the cable rack, ahead of other types of cable, or underneath the cable rack.

221 - 3. The cables are laced to every other (second) cross strap unless otherwise specified.

221 - 4. The first stitch used is the starting stitch, on each cross strap used. Then the Kansas City stitch is used to secure the lengths of cable to the cross strap. It is finished up with the ending stitch (Hawthorne knot).

222 - 1. The standard twenty color code is:
Blue
Orange
Green
Black
Slate
Blue-White
Blue-Orange
Blue-Green
Blue-Black
Blue-Slate
Orange-White
Orange-Green
Orange-Black
Orange-Slate
Green-White
Green-Black
Green-Slate
Black-White
Black-Slate
Slate-White

223 - 1. A fanned form is a group of conductors that originate at the butt of a cable or a corresponding point along the sewed portion of the cable form, pass through a fanning device and end at equipment terminals.

223 - 2. The maximum number of terminal blocks a horizontal fanned form can fan out to is five.

223 - 3. The maximum that a vertical form can fan out to is all the terminal blocks in one vertical only.

223 - 4. All bends, wire breakouts, and skinner lengths are predetermined before the forming begins on a sewed form.

223 - 5. If the maximum diameter of a sewed form is between 3/8 and $1\frac{1}{2}$ inches, a single strand of number 12 twine is used.

223 - 6. A form sewed with double strands of number 12 twine exceeds $1\frac{1}{2}$ inches in diameter.

223 - 7. Terminating consists of stripping the insulation from the conductors, placing the conductor in or on the proper terminal, and securing it.

223 - 8. The two methods of securing conductors to terminals are soldering or wire wrap.

223 - 9. Conductors may be untwisted only as far back as the fanning board of a terminal strip when terminating.

223 - 10. As a general rule, the shiner length for wire wrap terminations is $1\frac{1}{4}$ to $1\frac{1}{2}$ inches.

223 - 11. The minimum number of wraps for wire wrap terminations is five.

223 - 12. On a notched terminal, the wire is broken off at the back and (opposite the notch front) of the terminal.

224 - 1. Power is connected to the switching equipment bays after all the wiring in the bay is completed.

224 - 2. All power cables terminate at the fuse panel of the power board.

224 - 3. When terminating power cable, you should observe good wiring and soldering practices at all times, insuring that all connections are clean and tightly secured.

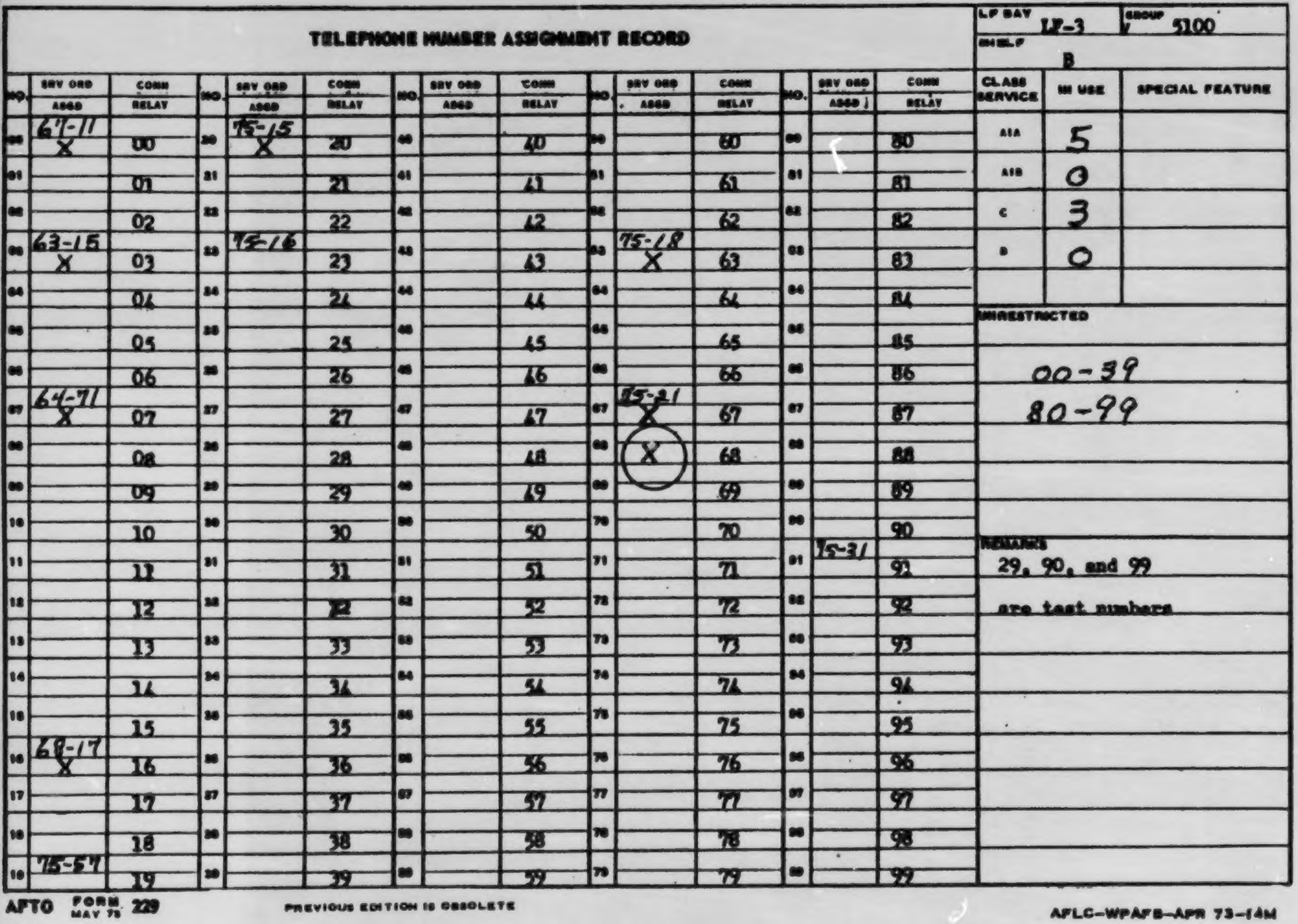
224 - 4. Power cables are attached to fuse panels and bus bars in the equipment bays.

225 - 1. You should annotate the floor plan drawing, in red pencil, to show the location of the new equipment in your exchange. Any notes you want to add will be in blue pencil.

225 - 2.
a. Blue.
b. Yellow.
c. Red.

225 - 3. At least two copies of affected drawings are marked up to reflect changes. One copy is forwarded for correcting the master drawings and to get new drawings made; the other copy is maintained in the organization, as the installation drawing until updated copies are received.

CHAPTER 5



TELEPHONE NUMBER ASSIGNMENT RECORD

NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY	NO.	SRV ORD ASGD	CONN RELAY
00	67-11 X	00	20	75-15 X	20	40		40	60		60	80		80
01		01	21		21	41		41	61		61	81		81
02		02	22		22	42		42	62		62	82		82
03	63-15 X	03	23	75-16	23	43		43	63	75-18 X	63	83		83
04		04	24		24	44		44	64		64	84		84
05		05	25		25	45		45	65		65	85		85
06		06	26		26	46		46	66		66	86		86
07	64-71 X	07	27		27	47		47	67	75-21 X	67	87		87
08		08	28		28	48		48	68	X	68	88		88
09		09	29		29	49		49	69		69	89		89
10		10	30		30	50		50	70		70	90		90
11		11	31		31	51		51	71		71	91	75-31	91
12		12	32		32	52		52	72		72	92		92
13		13	33		33	53		53	73		73	93		93
14		14	34		34	54		54	74		74	94		94
15		15	35		35	55		55	75		75	95		95
16	68-17 X	16	36		36	56		56	76		76	96		96
17		17	37		37	57		57	77		77	97		97
18		18	38		38	58		58	78		78	98		98
19	75-57	19	39		39	59		59	79		79	99		99

LF BAY LF-3

GROUP 5100

SHELF B

CLASS SERVICE	IN USE	SPECIAL FEATURE
A1A	5	
A1B	0	
C	3	
D	0	

UNRESTRICTED

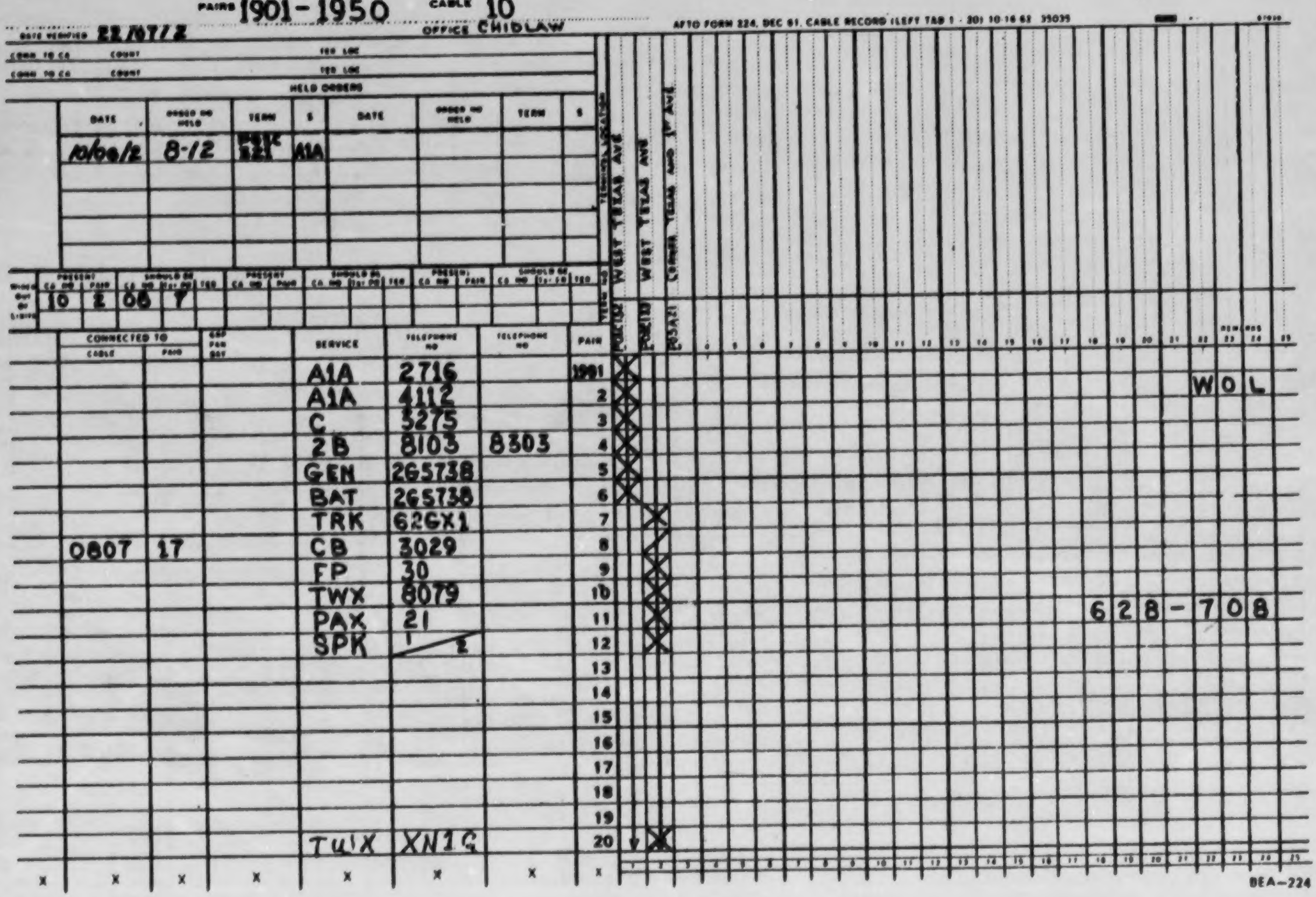
00-39
80-99

REMARKS

29, 90, and 99 are test numbers

AFTO FORM MAY 75 229 PREVIOUS EDITION IS OBSOLETE AFLC-WPAFB-APR 73-14M

Figure 1. AFTO Form 229 (answer for objective 226, exercise 1, a-e).



PAIRS 1901-1950 CABLE 10

DATE VERIFIED 22/07/2 OFFICE CHIDLAW

AFTO FORM 224, DEC 61, CABLE RECORD (LEFT TAB 1 - 20)

CONN TO CA COUNT TER LOC

CONN TO CA COUNT TER LOC

HELD ORDERS

DATE	ORDER NO HELD	TERM	S	DATE	ORDER NO HELD	TERM	S
10/08/2	8-12	[illegible]	A1A				

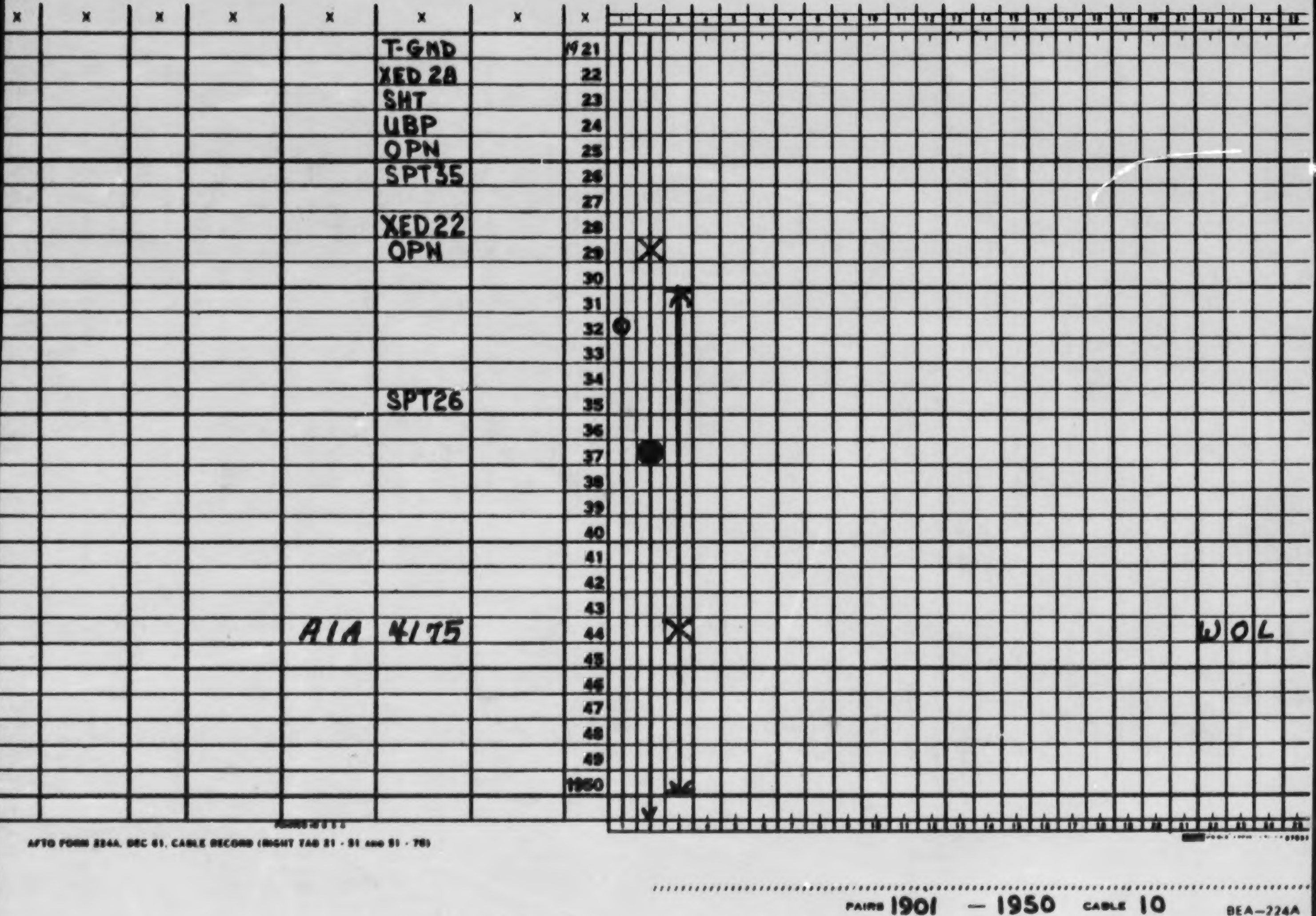
	PRESENT CA NO	PRESENT PAIR	SHOULD BE CA NO	SHOULD BE	TER
WIRED OUT OF LIMITS	10	2	06	7	

TERMINAL LOCATIONS: WEST TEXAS AVE; WEST TEXAS AVE; CORNER TEXAS AND 1st AVE

CONNECTED TO CABLE	CONNECTED TO PAIR	SERVICE	TELEPHONE NO	TELEPHONE NO	PAIR	WEST TEXAS AVE	WEST TEXAS AVE	REMARKS
		A1A	2716		1901	X		
		A1A	4112		2	X		WOL
		C	3275		3	X		
		2B	8103	8303	4	X		
		GEN	265738		5	X		
		BAT	265738		6	X		
		TRK	626X1		7		X	
0807	17	CB	3029		8		X	
		FP	30		9		X	
		TWX	8079		10		X	
		PAX	21		11		X	628-708
		SPK	1 / 2		12		X	
					13			
					14			
					15			
					16			
					17			
					18			
					19			
		TWX	XN1G		20	↓	X	

BEA-224

Figure 2. AFTO Form 224 (answer for objective [illegible], exercise 1, a-c).

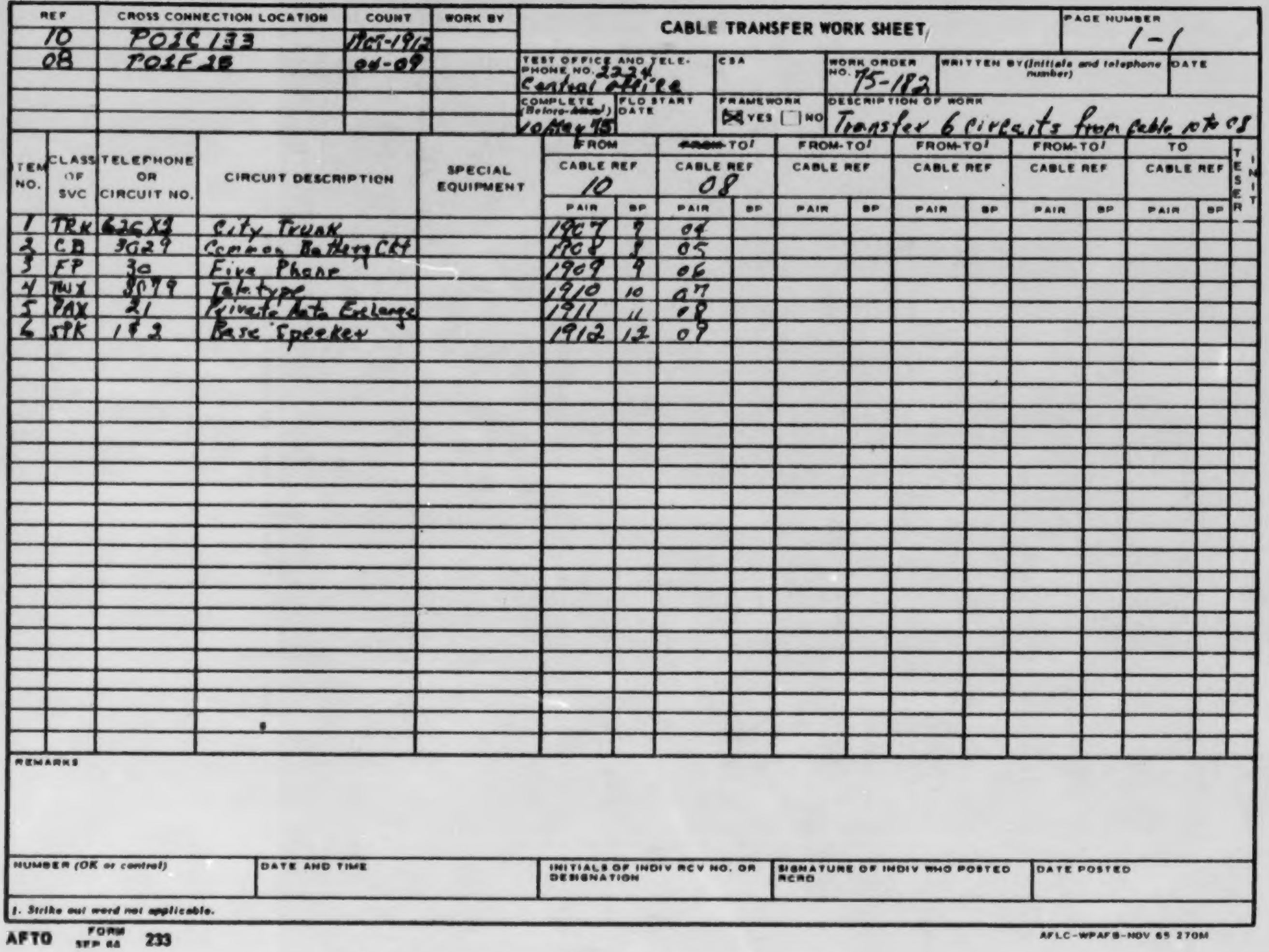


x	x	x	x	x	x	x	x	
					T-GND		1921	
					XED 28		22	
					SHT		23	
					UBP		24	
					OPN		25	
					SPT35		26	
							27	
					XED22		28	
					OPN		29	
							30	
							31	
							32	
							33	
							34	
					SPT26		35	
							36	
							37	
							38	
							39	
							40	
							41	
							42	
							43	
				A1A	4175		44	WOL
							45	
							46	
							47	
							48	
							49	
							1950	

AFTO FORM 224A, DEC 61, CABLE RECORD (RIGHT TAB 21 - 51 AND 51 - 76)

PAIRS 1901 — 1950 CABLE 10 BEA-224A

Figure 3. AFTO Form 224A (answer for objective 227, exercise 1, a-c).



REF	CROSS CONNECTION LOCATION	COUNT	WORK BY
10	PO1C 133	1907-1912	
08	PO1F 2B	04-09	

CABLE TRANSFER WORK SHEET

PAGE NUMBER 1-1

TEST OFFICE AND TELEPHONE NO. 2234 Central office

CSA

WORK ORDER NO. 75-182

WRITTEN BY (Initials and telephone number)

DATE

COMPLETE (Before-~~After~~) 10 May 75

FLD START DATE

FRAMEWORK ☒ YES ☐ NO

DESCRIPTION OF WORK Transfer 6 circuits from cable 10 to 08

ITEM NO.	CLASS OF SVC	TELEPHONE OR CIRCUIT NO.	CIRCUIT DESCRIPTION	SPECIAL EQUIPMENT	FROM CABLE REF 10 PAIR	FROM CABLE REF 10 BP	~~FROM~~-TO[1] CABLE REF 08 PAIR	~~FROM~~-TO[1] CABLE REF 08 BP	FROM-TO[1] CABLE REF PAIR	FROM-TO[1] CABLE REF BP	FROM-TO[1] CABLE REF PAIR	FROM-TO[1] CABLE REF BP	FROM-TO[1] CABLE REF PAIR	FROM-TO[1] CABLE REF BP	TO CABLE REF PAIR	TO CABLE REF BP	TESTER	INIT
1	TRK	626X9	City Trunk		1907	7	04											
2	CB	3629	Common Battery Ckt		1908	8	05											
3	FP	30	Fire Phone		1909	9	06											
4	TWX	8879	Teletype		1910	10	07											
5	PAX	21	Private Auto Exchange		1911	11	08											
6	SPK	1 & 2	Base Speaker		1912	12	09											

REMARKS

NUMBER (OK or control)	DATE AND TIME	INITIALS OF INDIV RCV NO. OR DESIGNATION	SIGNATURE OF INDIV WHO POSTED RCRD	DATE POSTED

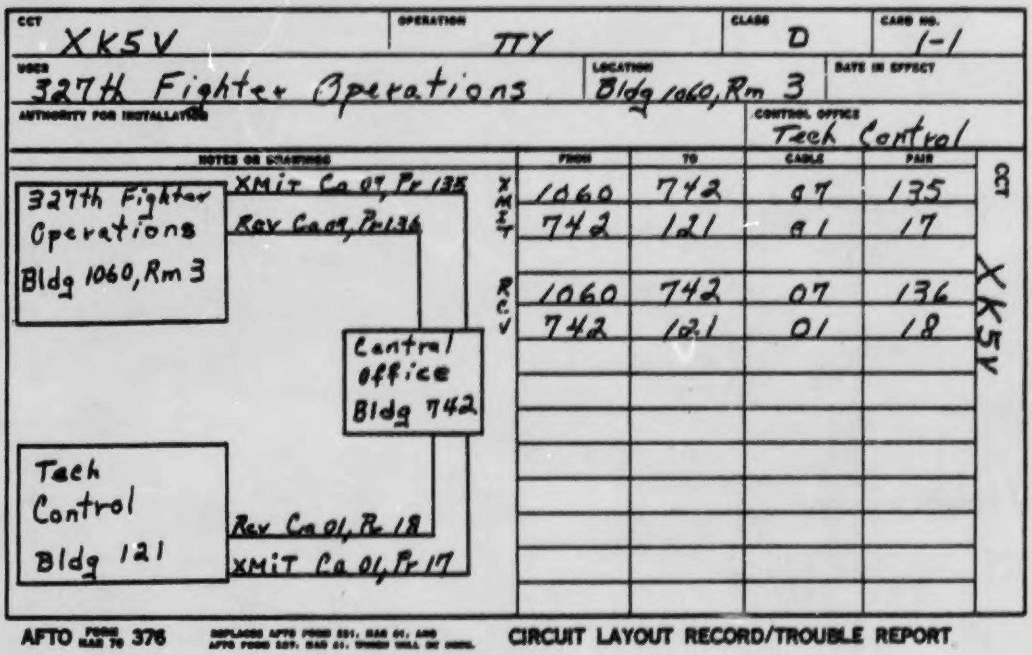
1. Strike out word not applicable.

AFTO FORM SEP 64 233

AFLC-WPAFB-NOV 65 270M

Figure 4. AFTO Form 233 (answer for objective 228, exercise 1).

229 - 1.



CCT XK5V | OPERATION TTY | CLASS D | CARD NO. 1-1

USER 327th Fighter Operations | LOCATION Bldg 1060, Rm 3 | DATE IN EFFECT

AUTHORITY FOR INSTALLATION | CONTROL OFFICE Tech Control

NOTES OR DRAWINGS

327th Fighter Operations
Bldg 1060, Rm 3

XMit Ca 07, Pr 135
Rcv Ca 07, Pr 136

Central office
Bldg 742

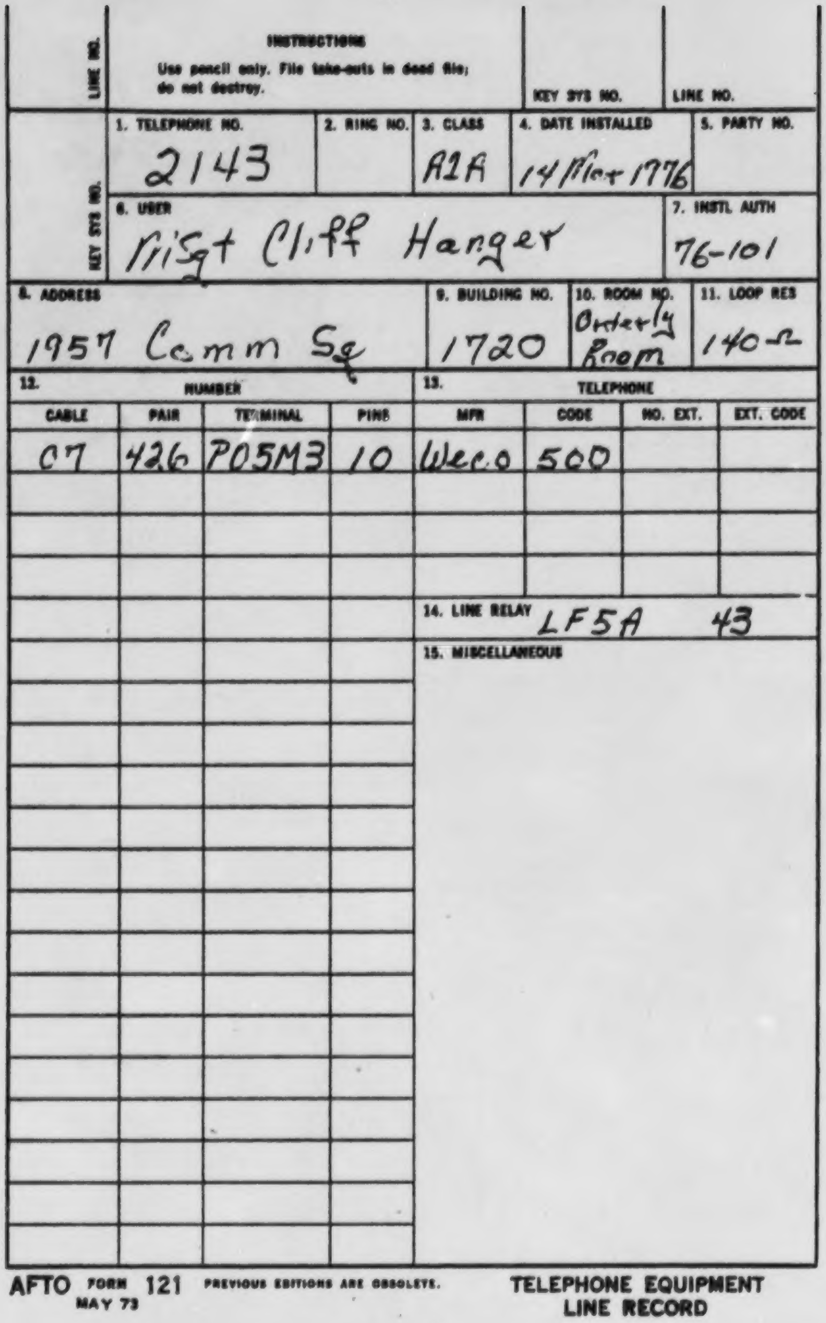
Tech Control
Bldg 121

Rcv Ca 01, Pr 18
XMiT Ca 01, Pr 17

	FROM	TO	CABLE	PAIR	CCT
XMIT	1060	742	07	135	XK5V
	742	121	01	17	
RCV	1060	742	07	136	
	742	121	01	18	

AFTO FORM MAR 70 376 [illegible] CIRCUIT LAYOUT RECORD/TROUBLE REPORT

Figure 5. AFTO Form 376 (answer for objective 229, exercise 1).



LINE NO.

INSTRUCTIONS

Use pencil only. File take-outs in dead file; do not destroy.

KEY SYS NO.

LINE NO.

KEY SYS NO.

1. TELEPHONE NO. 2143	2. RING NO.	3. CLASS A1A	4. DATE INSTALLED 14 Mar 1776	5. PARTY NO.

6. USER MSgt Cliff Hanger	7. INSTL AUTH 76-101

8. ADDRESS 1957 Comm Sq	9. BUILDING NO. 1720	10. ROOM NO. Orderly Room	11. LOOP RES 140-Ω

12. NUMBER				13. TELEPHONE			
CABLE	PAIR	TERMINAL	PINS	MFR	CODE	NO. EXT.	EXT. CODE
C7	426	P05M3	10	Weco	500		

14. LINE RELAY LF5A 43

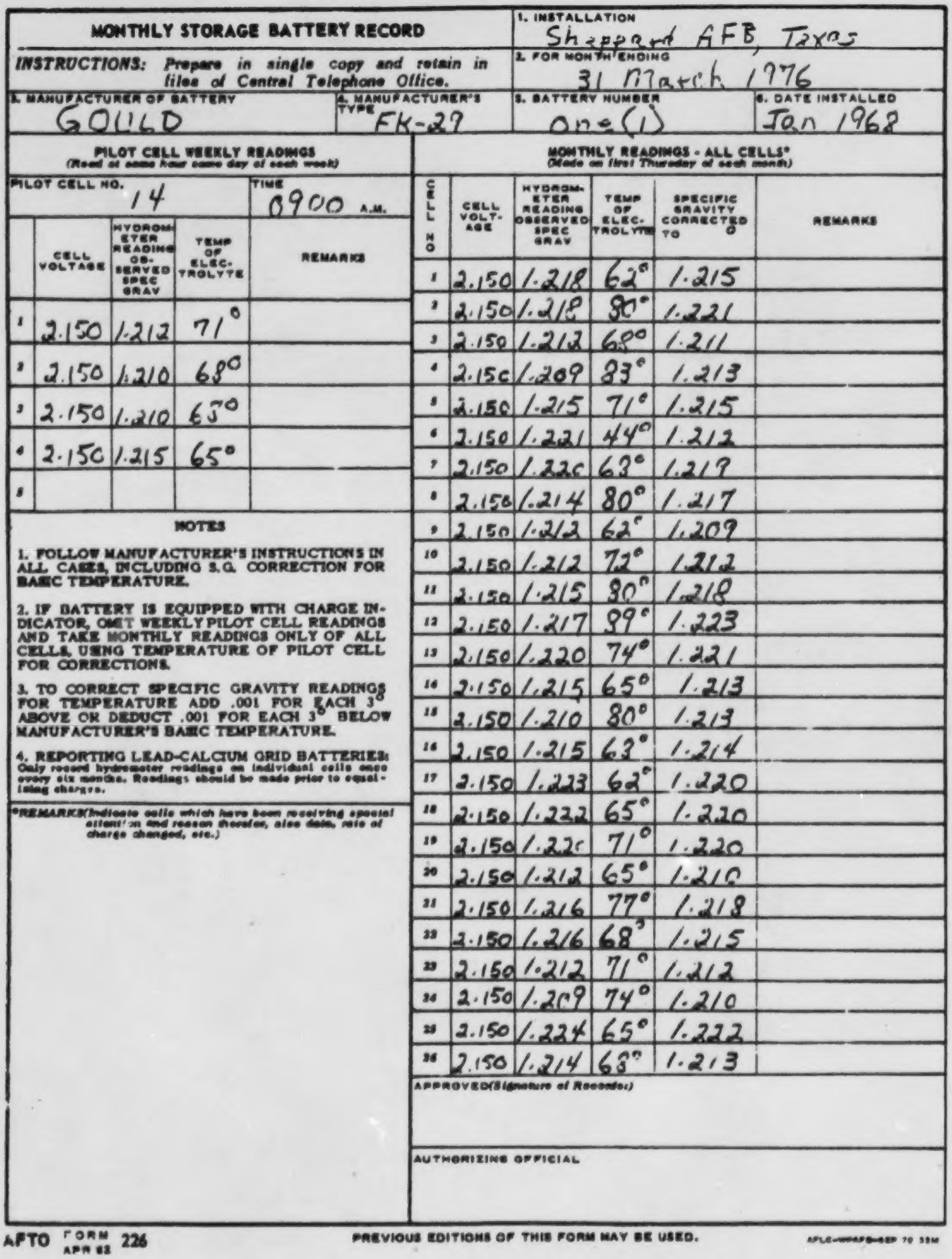
15. MISCELLANEOUS

AFTO FORM 121 MAY 73 PREVIOUS EDITIONS ARE OBSOLETE.

TELEPHONE EQUIPMENT LINE RECORD

Figure 6. AFTO Form 121 (answer for objective 230, exercise 1).

231 - 1.



MONTHLY STORAGE BATTERY RECORD

INSTRUCTIONS: Prepare in single copy and retain in files of Central Telephone Office.

1. INSTALLATION: Sheppard AFB, Texas
2. FOR MONTH ENDING: 31 March 1976
3. MANUFACTURER OF BATTERY: GOULD
4. MANUFACTURER'S TYPE: FK-27
5. BATTERY NUMBER: One (1)
6. DATE INSTALLED: Jan 1968

PILOT CELL WEEKLY READINGS
(Read at same hour same day of each week)

PILOT CELL NO. 14

TIME 0900 A.M.

	CELL VOLTAGE	HYDROMETER READING OBSERVED SPEC GRAV	TEMP OF ELECTROLYTE	REMARKS
1	2.150	1.212	71°	
2	2.150	1.210	68°	
3	2.150	1.210	65°	
4	2.150	1.215	65°	
5				

NOTES

1. FOLLOW MANUFACTURER'S INSTRUCTIONS IN ALL CASES, INCLUDING S.G. CORRECTION FOR BASIC TEMPERATURE.

2. IF BATTERY IS EQUIPPED WITH CHARGE INDICATOR, OMIT WEEKLY PILOT CELL READINGS AND TAKE MONTHLY READINGS ONLY OF ALL CELLS, USING TEMPERATURE OF PILOT CELL FOR CORRECTIONS.

3. TO CORRECT SPECIFIC GRAVITY READINGS FOR TEMPERATURE ADD .001 FOR EACH 3° ABOVE OR DEDUCT .001 FOR EACH 3° BELOW MANUFACTURER'S BASIC TEMPERATURE.

4. REPORTING LEAD-CALCIUM GRID BATTERIES: Only record hydrometer readings on individual cells once every six months. Readings should be made prior to equalizing charges.

*REMARKS (Indicate cells which have been receiving special attention and reason therefor, also date, rate of charge changed, etc.)

MONTHLY READINGS - ALL CELLS*
(Made on first Thursday of each month)

CELL NO	CELL VOLTAGE	HYDROMETER READING OBSERVED SPEC GRAV	TEMP OF ELECTROLYTE	SPECIFIC GRAVITY CORRECTED TO °	REMARKS
1	2.150	1.218	62°	1.215	
2	2.150	1.218	80°	1.221	
3	2.150	1.212	68°	1.211	
4	2.150	1.209	83°	1.213	
5	2.150	1.215	71°	1.215	
6	2.150	1.221	44°	1.212	
7	2.150	1.220	63°	1.219	
8	2.150	1.214	80°	1.217	
9	2.150	1.212	62°	1.209	
10	2.150	1.212	72°	1.212	
11	2.150	1.215	80°	1.218	
12	2.150	1.217	89°	1.223	
13	2.150	1.220	74°	1.221	
14	2.150	1.215	65°	1.213	
15	2.150	1.210	80°	1.213	
16	2.150	1.215	63°	1.214	
17	2.150	1.223	62°	1.220	
18	2.150	1.222	65°	1.220	
19	2.150	1.220	71°	1.220	
20	2.150	1.212	65°	1.210	
21	2.150	1.216	77°	1.218	
22	2.150	1.216	68°	1.215	
23	2.150	1.212	71°	1.212	
24	2.150	1.209	74°	1.210	
25	2.150	1.224	65°	1.222	
26	2.150	1.214	68°	1.213	

APPROVED (Signature of Recorder)

AUTHORIZING OFFICIAL

AFTO FORM APR 62 226 PREVIOUS EDITIONS OF THIS FORM MAY BE USED. AFLC-WPAFB-SEP 70 35M

Figure 7. AFTO Form 226 (answer for objective 231, exercise 1).

CHAPTER 6

232 - 1. d.
232 - 2. c.
232 - 3. b.
232 - 4. f.
232 - 5. a.
232 - 6. e.

233 - 1. a. When the magneto line subscriber operates his hand generator it causes relay RU to operate to its X contacts. The RU relay then operates fully through its X contacts 1 and 2 to battery on X contacts 21 and 22 of the RU. Contacts 3 and 4 of the RU close, placing ground out the LL lead to light the incoming lamp on the operator's telephone unit.

b. Following the operation of the RU relay in the magneto line circuit, the line lamp (INC), associated with the circuit, of the operator's telephone unit lights; due to the ground potential on the LL lead from the calling magneto line subscriber; that ground also operates the NA relay. If the night alarm (NA) switch is operated; the operating NA relay closes a path through its contacts 3 and 2, which operates the buzzer.

c. When the TALK-RING key of the operator's telephone unit is placed in the TALK position its 4D and 5D contacts place ground on the BL lead to the magneto line circuit; this shunts the RU relay in the magneto line circuit causing the RU relay to release.

d. When the key is placed in the TALK position its contacts: (1) 6D and 7D close a path from ground to operate the SW relay, (2) 4D and 5D close a path from ground to light the BSY lamp and out the BL lead to shunt the RU relay in the magneto line circuit, and (3) 2D and 3D and 2C and 3C close the transmission path between the operator and the subscriber.

233 - 2. a. The only thing that happens in the CB line circuit when the subscriber goes off-hook is that the INC line lamp for the circuit lights on the switchboard. It does this from ground on a line jack contact, through the subscriber's line loop, contacts of the line jack, to battery on the NA lead, through the INC lamp.

b. When the operator inserts the answer cord into the line jack it (1) opens the line jack contacts, which extinguishes the INC lamp and (2) completes a path from ground on the sleeve of the line jack operates the RS relay in the cord circuit through the sleeve of the answer cord. When the RS relay operates, it closes a path through its 21 and 22 and 24 and 25 contacts to operate the RB relay over the subscriber's loop. The rear supervision lamp may flash; but does not remain lit.

c. When the operator inserts the call cord into the called party's line jack (CB), the FS relay in the cord circuit operates from the ground on the sleeve of the line jack. When the FS relay operates, its 1 and 2 contacts close a path from ground to operate the front supervisory lamp; it also closes a partial path for the FB relay.

234 - 1. b.
234 - 2. d.
234 - 3. a.
234 - 4. f.
234 - 5. c.
234 - 6. e.

235 - 1. The trouble could be an open b-d winding in relay RU of the magneto line circuit; but the most likely problem is dirty contacts 23 and 24 of relay RU. Burnishing the contacts should clear the trouble.

235 - 2. The trouble is an open winding or windings in relay RE of the operator's circuit and requires that the coil be replaced. It cannot be a shorted capacitor C4, C5, or C6 as this would cause a fuse to blow.

235 - 3. This trouble is dirty contacts of relay FS; either 24 and 25 or 21 and 22. Burnishing the contacts will clear the trouble. The trouble affects only one cord circuit on the position eliminating the possibility of the operator's circuit (foldout 5).

236 - 1. a. A short is found using this test board by placing the Wheatstone bridge across the cable pair. This is done by placing the selector switch on step 4.

b. The line must be tested for battery potential prior to using the Wheatstone bridge as battery on the line will ruin the bridge.

236 - 2. a. You test for a battery potential on the ring side of the line under test by placing the selector switch on step 3 and operating the TEST REV key. If there is battery potential present, a reading is seen on the voltmeter.

b. You test for a ground potential on the tip side of the line *ONLY* after you have determined that no battery is present. Place the selector switch on step 5 and operate the Wheatstone bridge. If ground potential is present, a reading is obtained. NOTE: The tests performed individually in exercises 236-2,a and b can be performed with one test. Place the selector switch on step 2 and operate the TEST REV key. If the meter has moved to the right or up the meter scale, ground is present on the tip side and battery on the ring side.

237 - 1. When a magneto line circuit blows a fuse, the fuse alarm (FA) lamp lights to indicate that a fuse has blown. The lamp lights because contacts 1 and 2, of the operated FA relay, make the FA relay operate because when the fuse blew it closed a circuit from battery to the fuse alarm bar that runs between the fuse studs and which is connected to ground through the windings of the FA relay.

237 - 2. The lamp in figure 6-14 may not light for only two reasons when the bell rings: a burned out FA PILOT lamp or contacts 1 and 2 of relay FA are dirty. The corrective action amounts to burnishing the relay contacts or replacing the lamp. A continuity test using a test lamp or receiver will pin the trouble down to the specific spot causing the trouble.

237 - 3. There are two possibilities here: (1) the wing of the second blown fuse may not be touching the fuse alarm bar or (2) the fuse may be installed backwards shunting the circuit of the FA relay.

CHAPTER 7

238 - 1. The table of contents pages list the PMIs in numerical order by type and title, also the introduction page, the recommended schedule for accomplishment of routines page, and the suggestions page.

238 - 2. The introduction page contains three sections; purpose, scope, and responsibilities.

238 - 3. The general information paragraph contains the purpose of the particular routine, the approximate time required to perform the routine, and instructions concerning malfunctions found during the routine.

238 - 4. The materials required paragraph lists all the items necessary for the performance of a particular routine, except test equipment.

238 - 5. The procedures paragraph contains the step-by-step directions, sometimes including pictures, for performing the routine and expected test results.

239 - 1. Type 1 PMIs are performed to test for the proper operation of a switch or circuit under normal or nearly normal circuit operating conditions.

239 - 2. Type 2 PMIs are performed only when it has been determined that the equipment requires alignment or adjustment.

239 - 3. Types 1 and 3 PMIs are performed at the intervals suggested in the workcards, or more often if necessary for proper maintenance.

239 - 4. Type 3 PMIs are performed to keep the equipment clean and properly lubricated and to prevent the sluggish operation or nonoperation of equipment due to dirt and dust combining with the lubricant.

240 - 1. The heat coils associated with this subscriber's line should have blown immediately when the subscriber went off-hook. Replacement of the heat coils is required.

240 - 2. The strap of the C terminals between the LF and CONN terminals on the number terminal block is missing or open. The strap needs to be replaced or the cold solder joint redone.

240 - 3. The straps on the number block between the LF and CONN tip and ring terminals and possibly the C terminal are missing or open. Replacing the straps should clear the trouble. If the jumper were connected to the CONN T and R terminals, the subscriber could receive and not make calls.

240 - 4. The subscriber's line is grounded on the ring side by a shorted carbon block in the protector assembly of the MDF. Replacing the carbon block is the corrective action.

241 - 1. The circuits to the city trunks from the banks of the first selector are cross-connected at the IDF with jumpers. Both the city trunks and trunks from the banks of the selectors reach the IDF by cables.

241 - 2. The subscriber's cable pair is terminated to the line equipment by a jumper on the MDF.

241 - 3. The bottom and left-hand side terminals of the IDF terminal blocks both terminate equipment. Equipment interconnections are made on the top and right-hand side terminals of the IDF terminal blocks.

AU GAFS, AL (801033)1100

242

36251 02 S01 7511

SUPPLEMENTARY MATERIAL

CDC 36251

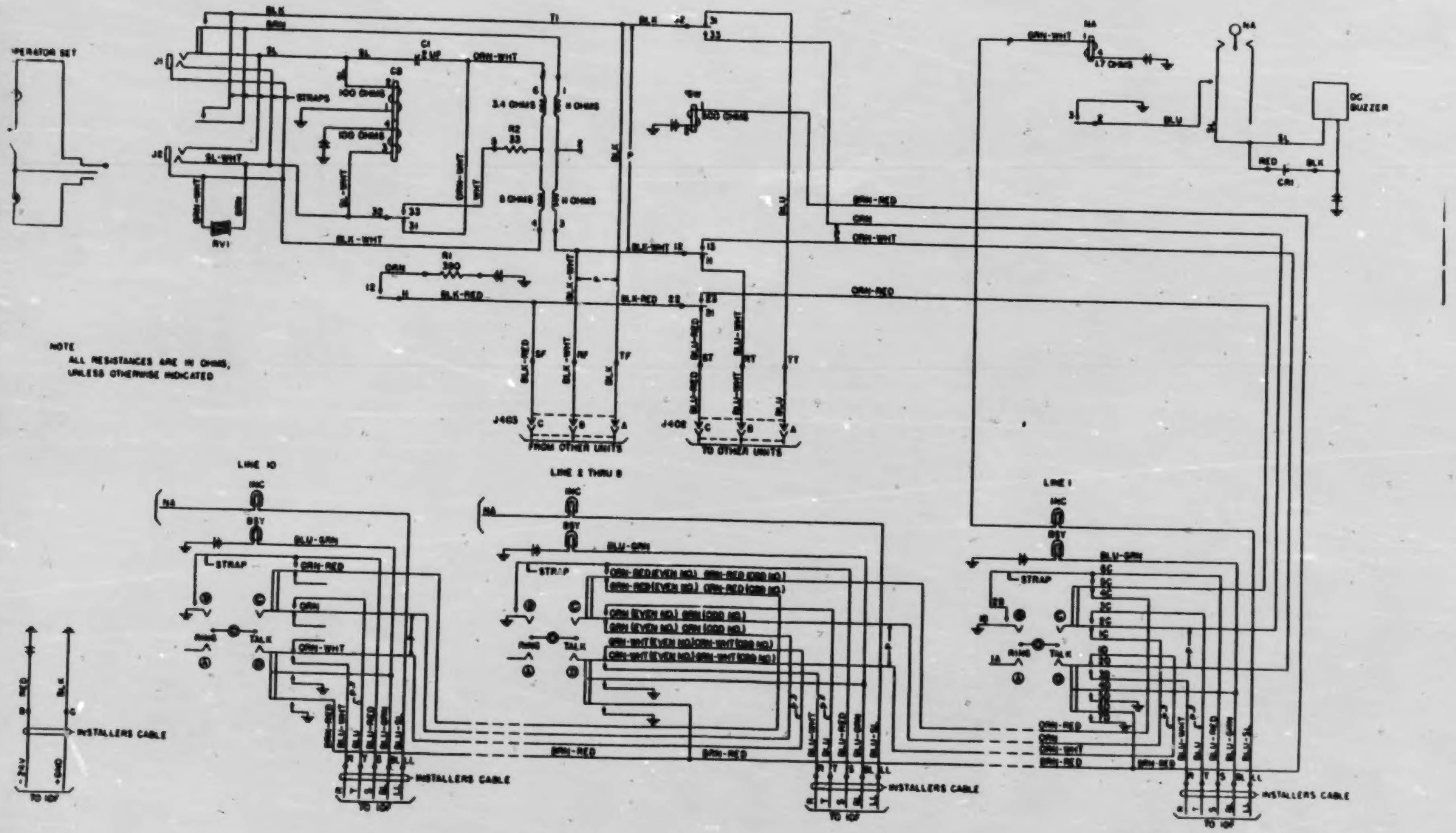
TELEPHONE SWITCHING EQUIPMENT REPAIRMAN (ELECTROMECHANICAL)

(AFSC 36251)

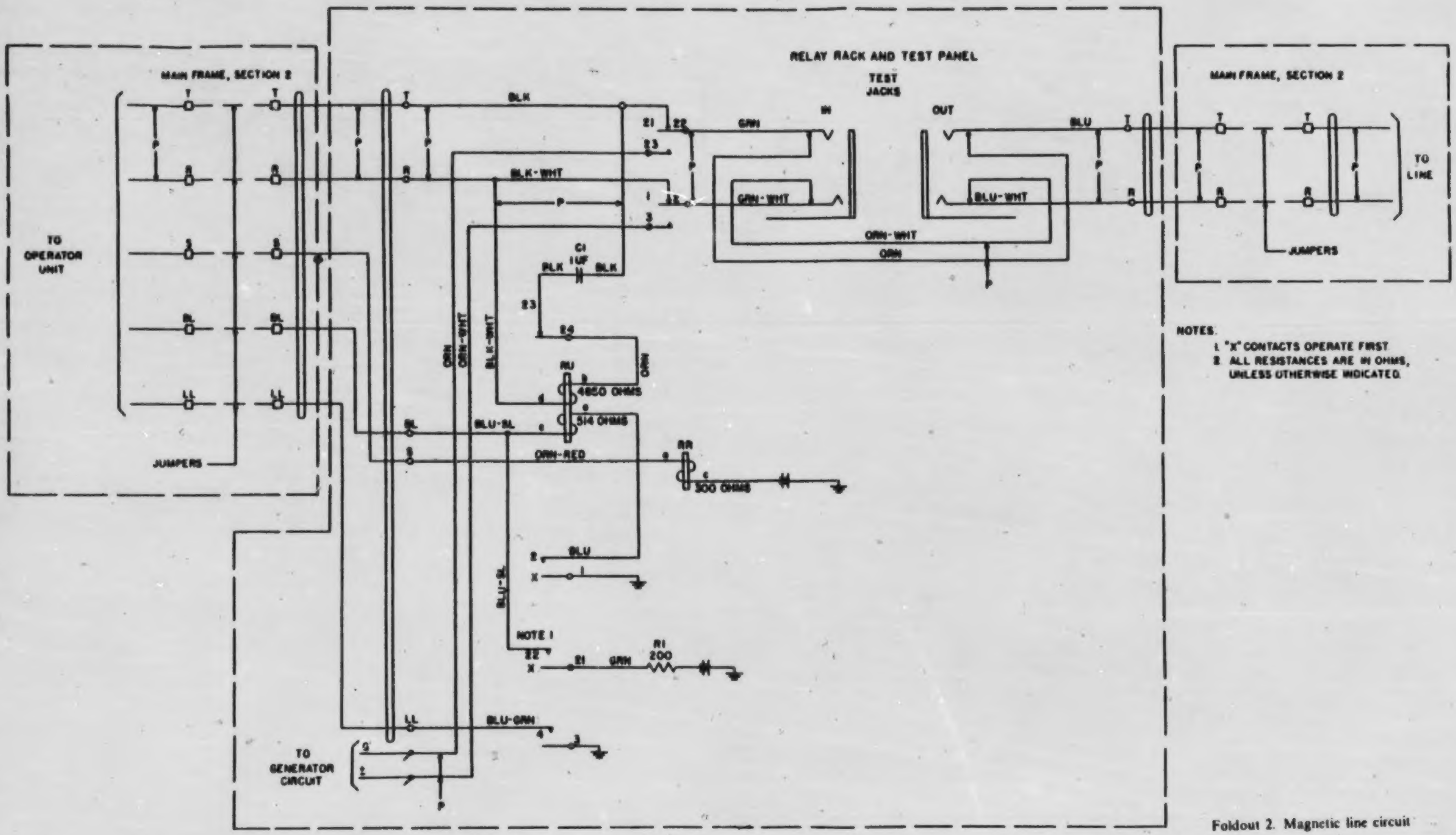
AU GAFS,AL(784140)1M

Foldouts 1 through 7

Extension Course Institute
Air University

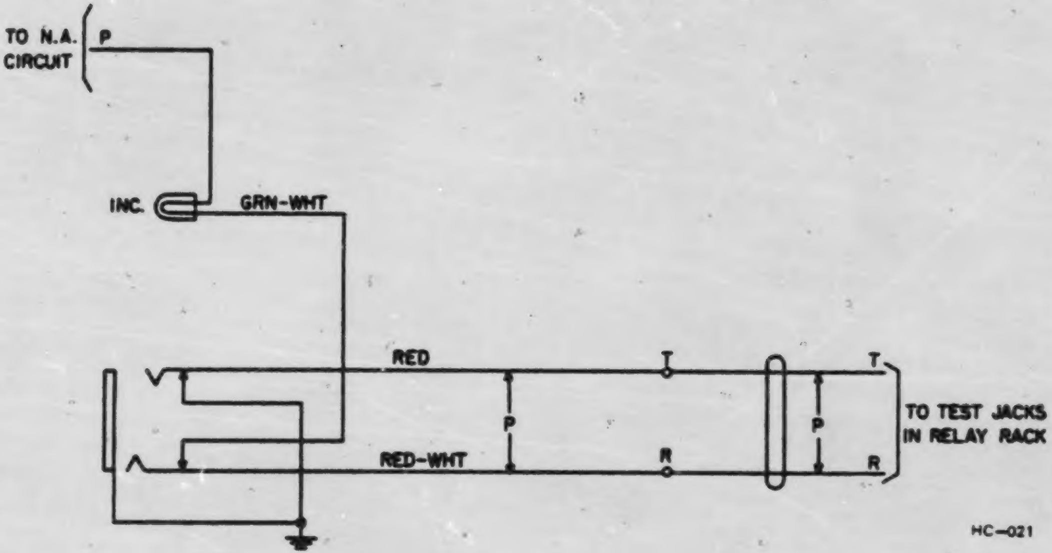


Foldout 1. Operator's telephone circuit.

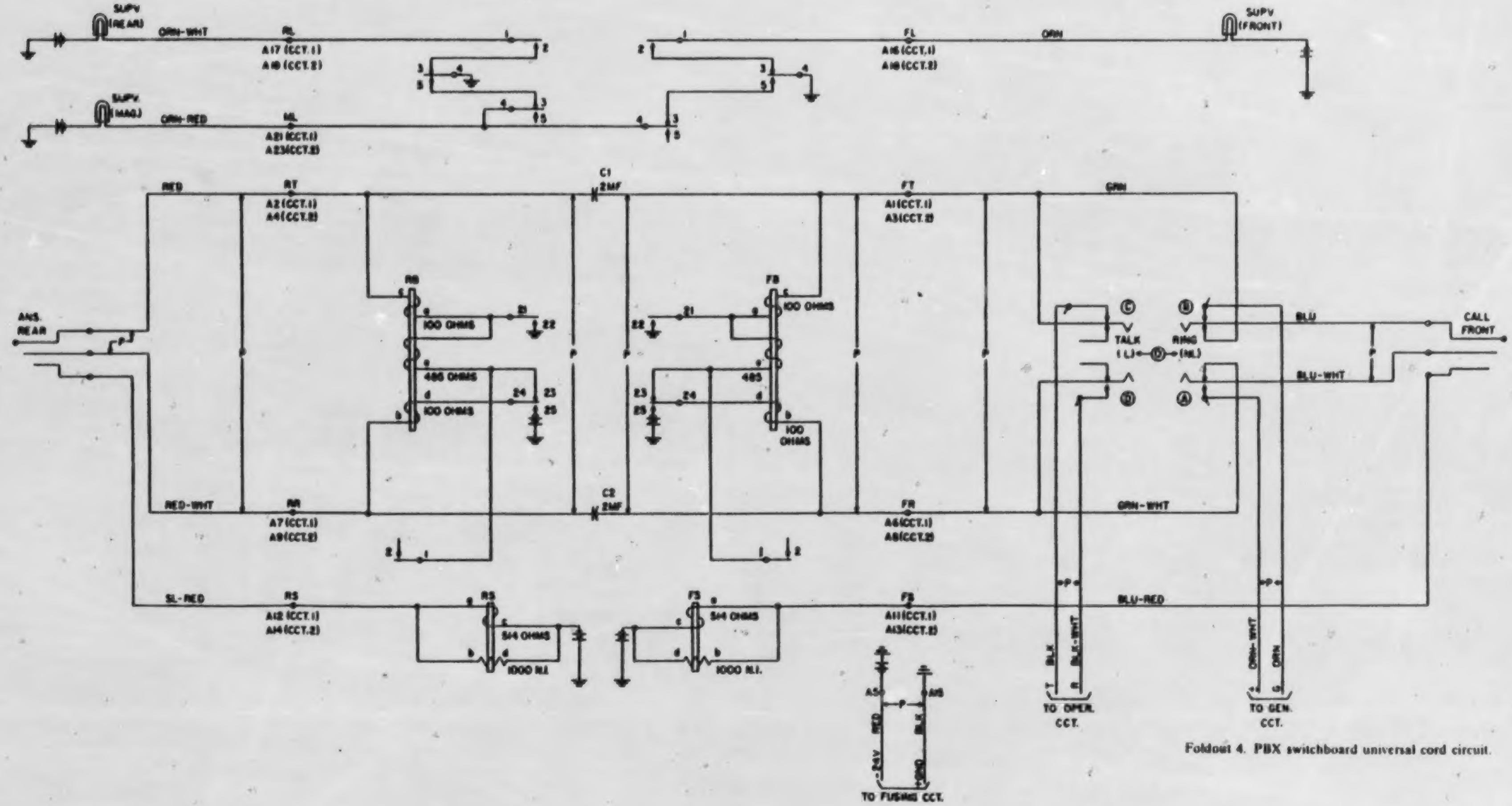


NOTES:
1. "X" CONTACTS OPERATE FIRST.
2. ALL RESISTANCES ARE IN OHMS, UNLESS OTHERWISE INDICATED.

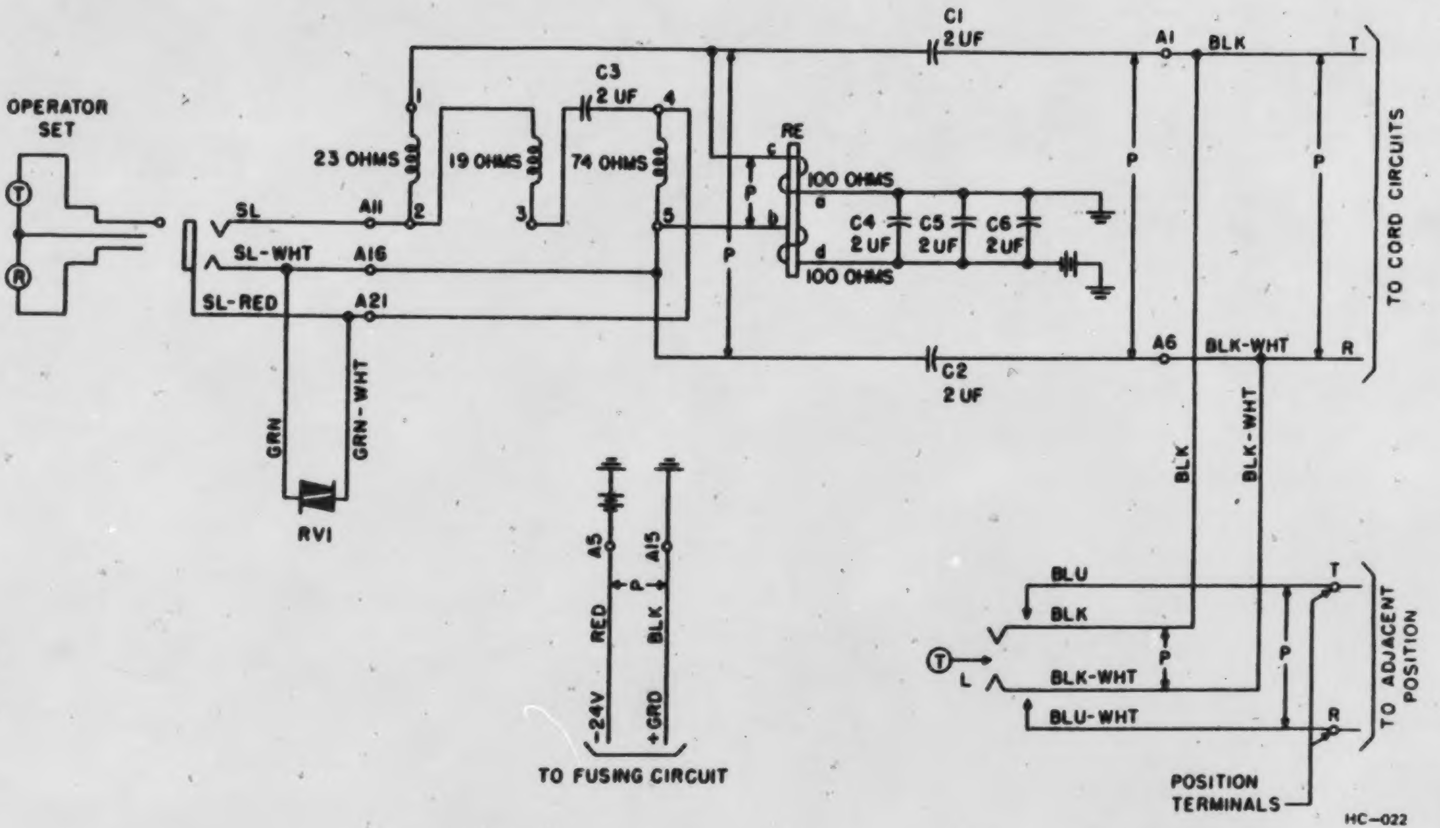
Foldout 2. Magnetic line circuit



Foldout 3. PBX switchboard common battery line circuit.



Foldout 4. PBX switchboard universal cord circuit.



Foldout 5. PBX switchboard operator's circuit.

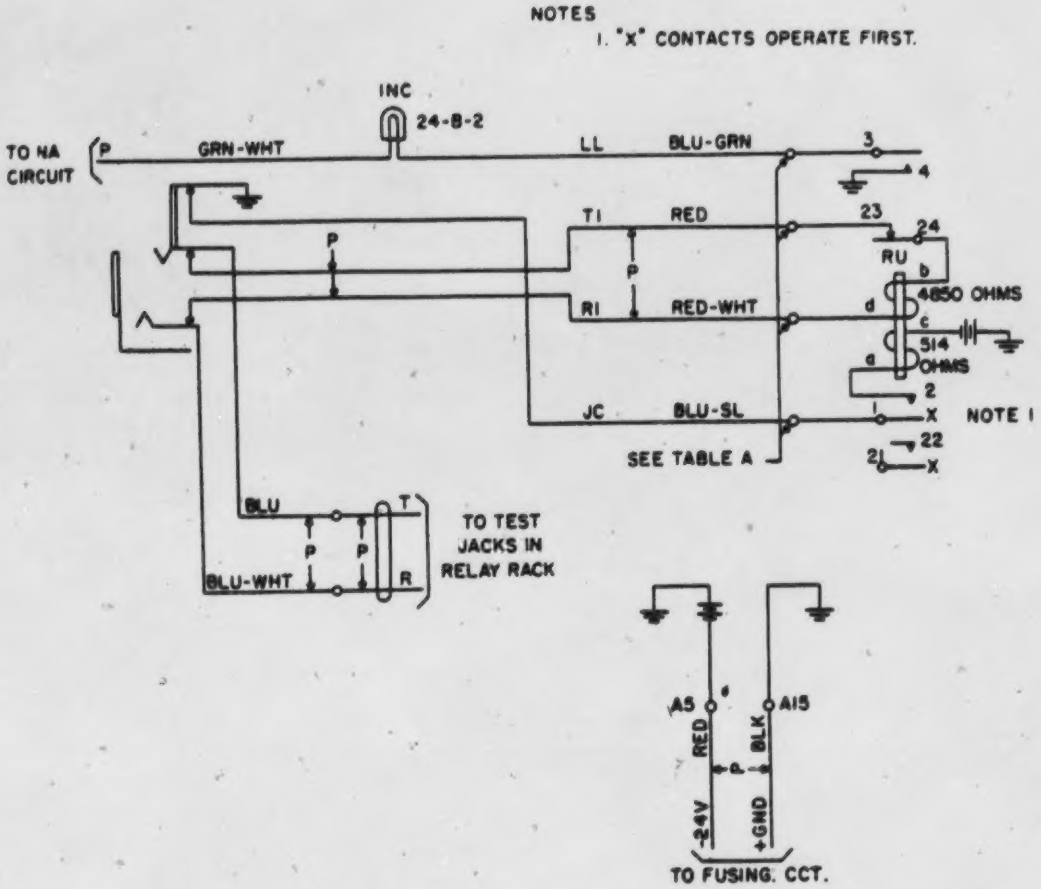
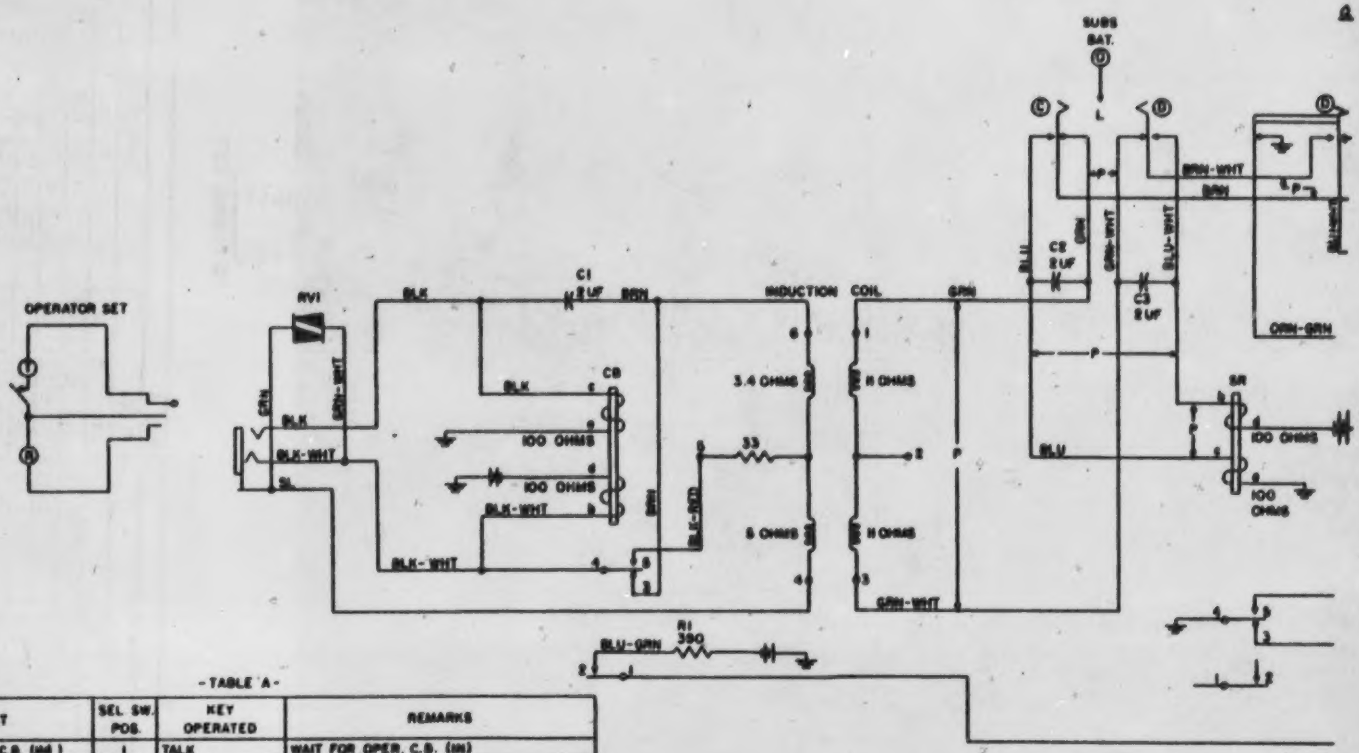


TABLE A

A PLUG						C PLUG						D PLUG				
	TI	RI	LL	JC			TI	RI	LL	JC			TI	RI	LL	JC
CCT. 1	A1	A6	A11	A16		CCT. 7	C1	C6	C11	C16		CCT. 14	D1	D6	D11	D16
CCT. 2	A21	A26	A22	A27		CCT. 8	C21	C26	C22	C27		CCT. 15	D21	D26	D22	D27
CCT. 3	A2	A7	A12	A17		CCT. 9	C2	C7	C12	C17		CCT. 16	D2	D7	D12	D17
CCT. 4	A3	A8	A13	A18		CCT. 10	C3	C8	C13	C18		CCT. 17	D3	D8	D13	D18
CCT. 5	A23	A28	A24	A29		CCT. 11	C23	C28	C24	C29		CCT. 18	D23	D28	D24	D29
CCT. 6	A4	A9	A14	A19		CCT. 12	C4	C9	C14	C19		CCT. 19	D4	D9	D14	D19
						CCT. 13	C5	C10	C15	C20		CCT. 20	D5	D10	D15	D20

HC—020

Foldout 6. PBX switchboard magnetic line circuit.



-TABLE A-

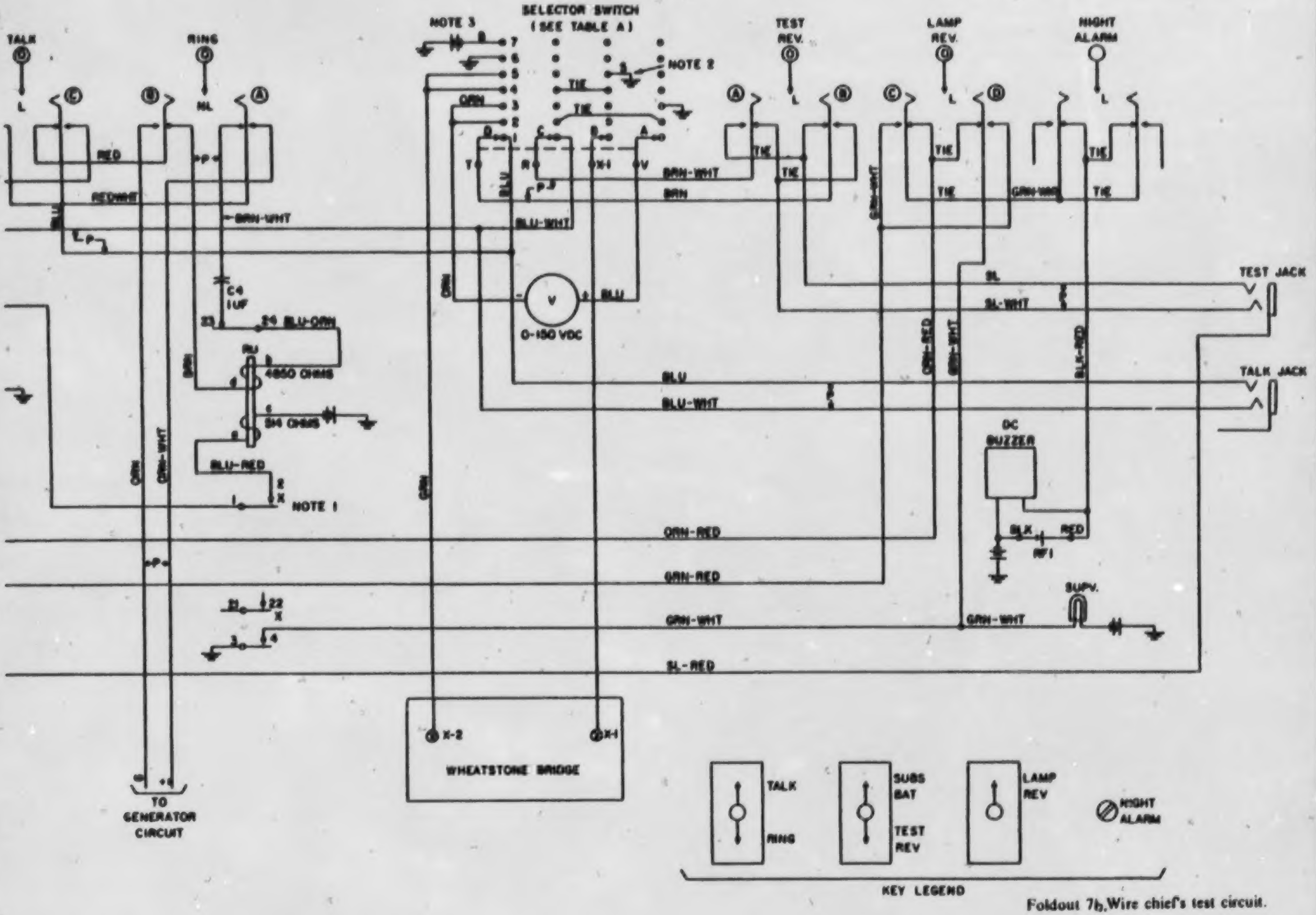
TEST	SEL. SW. POS.	KEY OPERATED	REMARKS
TALK (MAG OR C.B. (IN))	1	TALK	WAIT FOR OPER. C.B. (IN)
RING (MAG. OR C.B. (OUT))	1	RING	
C.B. (OUT)	1	TALK & SUBS BAT.	
LOOP POTENTIAL	2	NONE	OPERATE TEST REV. IF POLARITY IS WRONG
NEG POTENTIAL ON T	3	NONE	
NEG POTENTIAL ON R	3	TEST REV.	
BRIDGE (LOOP)	4	NONE	
BRIDGE (T TO GROUND)	5	NONE	
BRIDGE (R TO GROUND)	5	TEST REV.	
GROUND ON T	6	NONE	
GROUND ON R	6	TEST REV.	
BATTERY ON T	7	NONE	
BATTERY ON R	7	TEST REV.	

NOTES:

1. "X" CONTACTS OPERATE FIRST.
2. "S" GROUND RUNS TO GROUND STUD SEPARATELY.
3. "B" BATTERY FUSED SEPARATELY.
4. ALL RESISTANCES ARE IN OHMS; UNLESS OTHERWISE INDICATED.

Feldout 7a.

249



Foldout 7b, Wire chief's test circuit.

STOP– **1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.** **2. USE NUMBER 1 OR NUMBER 2 PENCIL.**

362 02 23

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

TELEPHONE FUNDAMENTALS AND MANUAL TELEPHONE SYSTEM

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that numerical sequence on answer sheet alternates across from column to column.
3. Use a medium sharp #1 or #2 black lead pencil for marking answer sheet.
4. Circle the correct answer in this test booklet. After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if at all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DON'TS:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #1 or #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (200) The relay operating time for fast-operating Strowger relays ranges from about

   a. 8 to 30 milliseconds.
   b. 8 to 45 milliseconds.
   c. 8 to 50 milliseconds.
   d. 8 to 60 milliseconds.

2. (200) Which of the following types of relays does not use a single wound coil?

   a. Slow-acting.
   b. Fast-operating.
   c. Slow-releasing.
   d. Differential.

3. (200) On a relay equipped with a standard lever armature, the

   a. armature has a mechanical advantage of approximately 2.75 to 1 in respect to the contact springs.
   b. contact springs have a mechanical advantage of approximately 2.75 to 1 in respect to the armature.
   c. ratio between the contact springs and the armature is approximately 1 to 1.
   d. armature ratio is such that the unit is classed as a slow-acting relay.

4. (200) The best reason for attaching a nonmagnetic residual plate to the armature is to offset the effect of

   a. magnetism retained in a relay armature and core.
   b. magnetism retained in a relay core and coil.
   c. incorrect mechanical adjustment.
   d. incorrect electrical adjustment.

5. (201) Relay adjustment is divided into how many major classifications?

   a. One.
   b. Two.
   c. Three.
   d. Four.

6. (201) The stroke setting is that distance between the

   a. flat part of the armature and the core when the armature is at normal.
   b. tip of the residual screw and the coil core when the armature is at normal.
   c. flat part of the armature and the core when the armature is in the operated position.
   d. tip of the residual screw and the coil core when the armature is in the operated position.

7. (202) What tool should you use to make the stroke setting on a relay?

   a. Contact spring bender.
   b. Offset screwdriver.
   c. Backstop bender.
   d. Duckbill pliers.

8. (202) What tool should you use to tension a relay's contact springs?

   a. Duckbill pliers.
   b. Longnose pliers.
   c. Offset screwdriver.
   d. Contact spring bender.

9. (203) Which adjustment is probably wrong if the contact springs have too much travel?

   a. Stroke.
   b. Airline.
   c. Residual.
   d. Armature arm.

10. (203) What adjustments, other than spring contacts 1 and 2, are affected by adjusting the armature arm?

    a. Residual and spring contact tension.
    b. Stroke and spring contact tension.
    c. Residual and stroke.
    d. Stroke and airline.

11. (204) The C-type Stromberg-Carlson relay is equipped with all of the following components except dual

    a. coils.
    b. armatures.
    c. armature clips.
    d. spring pile-ups.

12. (204) As viewed from the rear of the relay, which of the following statements best describes the method of numbering Stromberg-Carlson relay spring contacts?

    a. One to 10 for the left spring pileup and 11 to 20 for the right spring pileup.
    b. One to 20 for the left spring pileup and 21 to 40 for the right spring pileup.
    c. One to 10 for the right spring pileup and 11 to 20 for the left spring pileup.
    d. One to 20 for the right spring pileup and 21 to 40 for the left spring pileup.

13. (205) See Figure 1-32 of the text. What is the residual screw setting for relay XD?

    a. .004 inch.
    b. .006 inch.
    c. .007 inch.
    d. .009 inch.

14. (205) See Figure 1-32 of the text. What is the operate value, in milliamps, for adjusting relay SW?

    a. 14.5.
    b. 16.
    c. 19.
    d. 21.

15. (206) What size feeler gauges, larger and smaller than a residual specification of .012 inch, are used for adjusting an A-type relay with the armature. operated by hand?

    a. .001 inch larger and .001 inch smaller.
    b. .001 inch larger and .002 inch smaller.
    c. .002 inch larger and .001 inch smaller.
    d. .002 inch larger and .002 inch smaller.

16. (206) The preferred method for gauging make contacts is by adjusting the

    a. armature support plate mounting screw.
    b. armature residual screw.
    c. armature support plate.
    d. light spring contacts.

17. (207) When the armature of an A-type relay pulls up completely to the coil core, the make contacts do not make. If the residual adjustment is correct, what adjustment should be made?

    a. Pusher.
    b. Armature.
    c. Backstop.
    d. Armature support plate.

18. (208) Which of the following listed components plays a part in the vertical stepping of a Strowger switch?

a. Helical shaft spring.
b. Stationary detent.
c. Normal post cam.
d. Normal pin.

19. (208) The double detent is made up of the

a. vertical bank detent and the stationary detent.
b. vertical magnet and the vertical armature.
c. rotary magnet and the rotary armature.
d. vertical detent and the rotary detent.

20. (208) The stationary detent is

a. a guide for the switch shaft.
b. operated by the double detent spring.
c. used to maintain the switch shaft in the predetermined vertical position while going rotary.
d. used during the release function only and maintains mechanical control over the shaft and the release mechanism.

21. (208) Which one of the following actions best describes the purpose of the helical spring?

a. Increases tension during rotary stepping.
b. Prevents overstepping to 11th rotary position.
c. Returns wipers to home position during release.
d. Returns wipers from any rotary position during release.

22. (208) Restoring tension to a switch magnet armature is provided by

a. the stationary detent.
b. the release link.
c. a switch shaft.
d. a spring.

23. (208) Which of the following parts are associated with the vertical contact wiper assembly?

a. Wire bank, XX, and X banks.
b. Bank contacts and card holder.
c. Vertical bank and switch shaft.
d. Control contact bank and line contact banks.

24. (208) The bank wipers of the Strowger two-motion stepping switch will normally rest in a position

a. one step below and one step to the left of the first row of bank contacts.
b. on the same level but one step to the left of the first level of contacts.
c. one step below and one step to the right of the first level of contacts.
d. one step to the left of contact ten.

25. (208) A conversation thru a central office is completed thru which of the following switch components?

a. Line banks and associated wipers.
b. Line banks and control bank wipers.
c. Control banks and associated wipers.
d. Transmission both coils and control banks.

26. (209) What amount of tension is considered proper for the double dog spring?

a. 75 to 150 grams.
b. 150 to 250 grams.
c. 250 to 400 grams.
d. 300 to 450 grams.

27. (209) When a Strowger switch has completed vertical stepping and has taken two rotary steps, what is holding the shaft in the raised position?

a. Vertical detent.
b. Stationary detent.
c. Rotary armature backstop.
d. Vertical armature backstop.

28. (211) The most outstanding characteristic of the XY universal switch is its

a. versatility as linefinder, selector, or connector.
b. mechanical operating principles.
c. quiet, rapid connecting feature.
d. ease of repair.

29. (211) The X gear cluster drives the

a. tubular shaft and pinion gear.
b. cog roller and X-XX rack.
c. X and Y carriages.
d. Y stop bar.

30. (211) What switch position should we see if the "X" stepping mechanism has operated twice, and the "Y" stepping mechanism six times?

a. Position 4.
b. Position 6.
c. Position 26.
d. Position 62.

31. (212) The switching lever operates the

a. X-XX rack wipers.
b. release spring pileup.
c. Y off-normal spring pileup.
d. X off-normal and the XY overflow spring pileup.

32. (212) The XY switch was designed

a. to last over 40 years.
b. to be maintained with standard handtools.
c. for space requirements as the large consideration.
d. to eliminate all electrical noise on the transmission circuits.

33. (212) While making an X-Y stepping speed test, if both lamps flash and go out, the speed is

a. 25-45 steps per second.
b. 32-45 steps per second.
c. below 25 steps per second.
d. in excess of 45 steps per second.

34. (212) The X armature tip is adjusted to the tooth of the X gear cluster. This adjustment sets the

a. position of the X drive pawl.
b. X ejector pawl bracket.
c. X stopping action.
d. X retaining pawl.

35. (212) The Y retaining pawl is adjusted

a. the same as the Y armature.
b. to the teeth in the cog roller.
c. with the Y stop bar disengaged.
d. to the release magnet extension arm.

36. (214) With respect to a vibrating body, condensations and rarefactions occur

    a. at different times in opposite directions.
    b. at the same time in opposite directions.
    c. at the same time in the same direction.
    d. in a vacuum as well as the open air.

37. (214) Which of the following cannot be computed from a graphed representation of a pure tone sound wave?

    a. Power.
    b. Period.
    c. Amplitude.
    d. Frequency.

38. (214) What are the two most important lities of a sound wave from the standpoint of voice communications?

    a. Amplitude and period.
    b. Period and frequency.
    c. Frequency and distance.
    d. Frequency and amplitude.

39. (214) The human ear can detect sounds from about

    a. 20 hertz to about 20,000 hertz.
    b. 200 hertz to about 20,000 hertz.
    c. 20 hertz to about 30,000 hertz.
    d. 200 hertz to about 30,000 hertz.

40. (214) How does the signal on the line compare with the sound at the transmitter?

    a. Same frequency.
    b. Same wave shape.
    c. Same relative amplitudes.
    d. In all of the above ways.

41. (214) What are the three basic parts of a receiver?

    a. Magnet, coil, and a frame.
    b. Coil, frame, and a diaphragm.
    c. Diaphragm, magnet, and a coil.
    d. Frame, diaphragm, and a magnet.

42. (214) What is the effect of variations in strength of the magnetic field in a telephone receiver?

    a. Diaphragm vibrates.
    b. Line current varies.
    c. Circuit resistance varies.
    d. Transmitted sound is reproduced.

43. (215) What does the action of a linefinder in an automatic office equate to in a manual system?

    a. Line lamp operating.
    b. Operator asking, "Number please?"
    c. Operator plugging a cord into the line jack.
    d. Operator plugging a cord into the jack of the called party.

44. (215) What is the maximum number of lines that can be served by an automatic central office using a linefinder, two selectors, and a connector for each link?

    a. 1,000.
    b. 2,000.
    c. 10,000.
    d. 20,000.

45. (216) Into how many main parts is a C-E scheme divided?

    a. 2.
    b. 3.
    c. 4.
    d. 5.

46. (216) Which of the following is included in the general information division of a C-E scheme?

a. List of material.
b. Test instructions.
c. Functional description.
d. Technical supporting data.

47. (216) Drawings that are furnished with a C-E scheme package are classified as

a. interim and installation.
b. installation and general.
c. station and interim.
d. general and station.

48. (217) The installation team inspects the facility against the C-E scheme package prior to starting work to

a. determine if anything that will affect the installation was overlooked.
b. insure that any construction or repairs to the building are complete.
c. gain the necessary agreements from facility supervisors.
d. accomplish all of the above.

49. (218) Floor markers should be placed in buildings to

a. provide the installer with a positive means of locating equipment.
b. eliminate the need for measuring and marking reference lines.
c. provide four-way alignment of equipment being installed.
d. mark the location where the MDF is to be installed.

50. (219) For installing floor angles, a pilot hole should be drilled if the angle hole in the floor is to have a diameter in excess of

a. 1/4 inch.
b. 3/8 inch.
c. 1/2 inch.
d. 5/8 inch.

51. (219) When lining up floor angles, what line is used to mark the mounting hole centerline?

a. Reference line A-A.
b. Reference line B-B.
c. Vertical face line.
d. Horizontal face line.

52. (220) What are the standard widths of ladder-type cable racks?

a. 6, 9, 12, 18, and 22 inches.
b. 6, 9, 15, 18, and 21 inches.
c. 9, 12, 15, 18, and 21 inches.
d. 9, 12, 15, 18, and 22 inches.

53. (220) What hardware is used when connecting one length of cable rack to another?

a. J bolts.
b. Stringer.
c. Corner clamps.
d. Straight clamps.

54. (221) Which of the following types of cable is listed ahead of the normal installation sequence?

a. Power.
b. Lead covered.
c. Station ground.
d. Miscellaneous wires.

55. (221) What is used to cut power cable?

a. Saber saw.
b. Boltcutters.
c. Cable shears.
d. Electrician's knife.

56. (221) Cables are normally secured to ladder-type cable racks with lacing twine at every

a. cross strap.
b. second cross strap.
c. third cross strap.
d. fourth cross strap.

57. (222) Which color is the tracer of the second group of 20 conductors in a cable?

a. Blue.
b. Slate.
c. Black.
d. Orange.

58. (222) What is the eleventh color of the standard 20 color code?

a. Blue-white.
b. Slate-white.
c. Green-white.
d. Orange-white.

59. (223) What does the term butting mean with respect to cable?

a. Making a length-wise cut through the sheath.
b. Making a circular cut through the sheath.
c. Taping the sheath to prevent raveling.
d. Removing the sheath at a given point.

60. (223) Fanned conductors are cut off how many inches beyond the face of the front edge of the terminal strip?

a. 3.
b. 4.
c. 6.
d. 8.

61. (223) Sewed forms are used for cables which terminate

a. on the vertical side of the MDF.
b. on the horizontal side of the MDF.
c. in the switchboard.
d. in the DTA.

62. (223) How many feet back from the end of a 16-foot sewed form, do the spare pairs extend?

a. 2.
b. 4.
c. 6.
d. 8.

63. (223) When terminating at a notched terminal, the wire is broken off in the

a. back, opposite the notch, after 1 1/2 wraps.
b. back, opposite the notch, after 1/2 wrap.
c. notch, after two wraps.
d. notch, after one wrap.

64. (223) As a general rule, the length of the shiner that provides the proper number of wraps for a wire wrap terminations is

a. 1 1/4 to 1 1/2 inches.
b. 2 to 2 1/4 inches.
c. 1 3/4 to 2 inches.
d. 3/4 to 1 inch.

65. (224) Which power cables are terminated at the fuse panel of the power board?

a. All of the power cables.
b. Those terminated at bus bars.
c. Those terminated in equipment bays.
d. All power cables one inch or larger in size.

66. (225) There are how many types of C-E plant-in-place records?

a. Three.
b. Four.
c. Five.
d. Six.

67. (225) Which of the following parts of the installation records are listed separately because of their importance?

a. Catalog documents.
b. Base C-E records.
c. Interim records.
d. C-E schemes.

68. (225) On plant-in-place drawings, the color yellow is used to identify

a. an interim change pending an engineering change order.
b. deleted equipment or notes.
c. notes to the engineer or draftsman.
d. the addition of equipment.

69. (226) What could be the effect if an entry on AFTO Form 229 under SER ORD ASGD is omitted?

a. The work order AF Form 1075 could never be completed.
b. Two telephones could be connected to the same line.
c. Any repair work needed on the subset cannot be accomplished because the telephone does not exist.
d. The maintenance man would never know about the omission.

70. (226) There is an A1A recorded in the class of service block on AF Form 1075. This means the telephone service is

a. unrestricted.
b. special number.
c. unrestricted paid for by subscriber.
d. restricted for official on base calls.

71. (227) Refer to Figure 5-1 of the text. The AF Form 1075 lists a telephone to be installed as an A1A class of service. What choice of line number is there in the 3100 group?

a. 00.
b. 05.
c. 11.
d. 20.

72. (227) If a technician is to assign data to a telephone service order, he will find the necessary distribution information on the

a. AFTO Form 224, Cable Record.
b. AFTO Form 233, Cable Transfer Worksheet.
c. AFTO Form 229, Telephone Number Assignment.
d. AF Form 1075, Communications Service Order.

73. (228) When transferring telephones from one area to another, the form involved is

a. AFTO Form 121.
b. AFTO Form 229.
c. AFTO Form 233.
d. AFTO Form 376.

74. (228) Information on circuits and equipment needed for filling out an AFTO Form 233 can be obtained from

a. AFTO Form 121 and 224 series.
b. AFTO Form 226 and 224 series.
c. AFTO Form 376 and 226 series.
d. AFTO Form 121 and 376 series.

75. (229) When a trouble on a line occurs, the trouble information is recorded on

a. AFTO Form 224 series.
b. AFTO Form 226 series.
c. AFTO Form 229 series.
d. AFTO Form 376 series.

76. (230) All except two items of information needed to fill out an AFTO Form 121 can be extracted from AF Form 1075. These items are the

a. date installed and telephone number.
b. loop resistance and line relay number.
c. type of service and instrument information.
d. installation authority and telephone number.

77. (230) What is the reverse side of the line record form used for?

a. Second party information.
b. Miscellaneous information.
c. Troubles reported information.
d. Type of instrument information.

78. (231) Pilot cells are read and recorded

a. hourly.
b. daily.
c. weekly.
d. monthly.

79. (232) Which of the supervisory lamps listed below is not found on the keyshelf of the AN/FTA 13 PBX switchboard?

a. Magneto.
b. Call cord.
c. Answer cord.
d. Common battery.

80. (232) The switchboard operator of a manual system monitors conversations by operating the

a. talk key for a given cord and operating the push-to-talk switch.
b. monitor key for a given cord and operating the push-to-talk switch.
c. monitor key for a given cord and not operating the push-to-talk key on the handset.
d. talk key for a given cord and not operating the push-to-talk key on the handset.

81. (232) What is the range of the voltage of the ringing current produced by the power supply for the AN/FTA 13 manual telephone system?

a. 75 to 90.
b. 80 to 90.
c. 75 to 95.
d. 80 to 95.

82. (233) Refer to foldout 1. What causes relay RR in foldout 2 to operate?

a. Ground through contacts 1B and 2B of the ring key.
b. Ground through contacts 4D and 5D of the talk key.
c. Ground through contacts 6D and 7D of the talk key.
d. Ground on the LL lead to the NA relay.

83. (233) Refer to foldout 1. The ground potential through contacts 4D and 5D of the talk key in the operator's telephone unit

a. holds relay RR in foldout 2 operated during outgoing calls.
b. holds relay RU in foldout 2 operated during outgoing calls.
c. shunts relay RR in foldout 2 during incoming calls.
d. shunts relay RU in foldout 2 during incoming calls.

84. (233) Refer to foldout 3. What causes the INC lamp of a common battery line to light?

a. The operator closes the line loop.
b. The subscriber closes the line loop.
c. Battery from the night alarm circuit.
d. Ground on the sleeve of the line jack.

85. (233) Refer to foldout 4. When the call cord supervisory lamp of the cord circuit lights, a

a. magneto line subscriber's phone is on-hook.
b. magneto line subscriber's phone is off-hook.
c. common battery line subscriber's phone is on-hook.
d. common battery line subscriber's phone is off-hook.

86. (234) Testing a circuit for continuity is a part of which troubleshooting step?

a. Test.
b. Analyze.
c. Clear the fault.
d. Point-by-point elimination.

87. (234) Which troubleshooting step is being accomplished when you perform an operational equipment check?

a. Test.
b. Analyze.
c. Clear the fault.
d. Point-by-point elimination.

88. (235) Refer to foldout 6. What is the trouble if a PBX magneto line circuit RU relay fails to operate when the subscriber operates the hand generator of his telephone?

a. Contacts 23 and 24 of the RU relay are shorted.
b. Contacts 1 and 2 of the RU relay are shorted.
c. The a-c winding of the RU relay is open.
d. The b-d winding of the RU relay is open.

89. (236) Refer to figure 6-4 of the text. What type of meter is mounted on the face equipment of the AN/FTA 13 test panel?

a. Ammeter.
b. Ohmmeter.
c. Voltmeter.
d. Multimeter.

90. (236) Refer to foldout 7. What is the test indication, if a meter reading is obtained on the AN/FTA 13 test panel with the selector switch on step 5?

a. Ground on the ring.
b. Ground on the tip.
c. Battery on the ring.
d. Battery on the tip.

91. (237) What is the output DC voltage of the AN/FTA 13 system's power supply?

a. 18 volts.
b. 24 volts.
c. 36 volts.
d. 48 volts.

92. (237) What potential is on the fuse bar that runs between the fuse mounting studs in the AN/FTA 13 manual system?

a. Resistance battery.
b. Resistance ground.
c. Battery.
d. Ground.

93. (238) Which of the following statements best describes the contents of the "Recommended schedule for accomplishment of routines," page in a workcard-type tech order?

a. Routine number, type of operation, maximum time interval.
b. Type of operation, routine title, maximum time interval.
c. Type of operation, routine title, minimum time interval.
d. Routine number, type of operation, minimum time interval.

94. (238) The general information section in a workcard-type TO contains the the purpose of the routine,

a. scope of responsibility, and approximate time required to perform the PMI.
b. scope of responsibility, and test equipment required to perform the PMI.
c. scope of responsibility, and instructions for corrective actions when measurements do not meet tolerances.
d. approximate time required to perform the PMI, and instructions for corrective action when measurements do not meet tolerances.

95. (239) A service routine is directly related to

a. equipment lubrication.
b. proper adjustment.
c. circuit operation.
d. proper alignment.

96. (239) What is a type 3 PMI routine called?

a. Service.
b. Alignment.
c. Adjustment.
d. Performance.

97. (240) The line protector assemblies in a telephone switching center are attached to

a. verticals of the IDF.
b. verticals of the MDF.
c. horizontals of the MDF.
d. horizontals of the IDF.

98. (240) The heat coil operates an alarm immediately if the line current is at least

a. 350 milliamperes.
b. 400 milliamperes.
c. 450 milliamperes.
d. 500 milliamperes.

99. (241) Vertical and horizontal equipment terminations are made on which side of the distributing frame terminal boards?

a. Top and left.
b. Top and right.
c. Bottom and left.
d. Bottom and right.

100. (241) Conductors of the cables from the linefinders terminate at the

a. upper terminals of the horizontal terminal boards.
b. terminals at the right of the vertical terminal boards.
c. terminals at the left of the vertical terminal boards.
d. lower terminals of the horizontal terminal boards.

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TELEPHONE SWITCHING EQUIPMENT REPAIRMAN (ELECTROMECHANICAL)

(AFSC 36251)

Volume 3

Strowger Step-by-Step Telephone System

Extension Course Institute

Air University

Preface

TELEPHONE switching equipment (central office) may at first seem somewhat complicated. However, the fundamental operations performed are possible because the major circuits, which are common to all telephone switching center equipment installations, are nothing more than unique combinations of several simple circuits. The operations resulting from the linking together of these circuits are obtained because of the chain reactions based on the accurate design of the equipment and each separate circuit. With the properly installed equipment adjusted carefully to the proper clearances, tolerances, and current values, the end result is prompt connection between the calling and the called telephone, whenever such connection is available.

To understand how each type of equipment and its associated circuits can make rapid telephone connections accurately, you must study each type of telephone equipment separately. In Volume 2 you were given general information about the principles and theory of telephone switching equipment. In this volume, our discussion will be limited to the application of that fundamental information when step-by-step equipment is used to perform the required switching functions. XY telephone equipment system will be discussed in a similar manner in Volume 4 of this course.

There are 10 schematic foldouts included with this volume. These foldouts are printed and bound as a separate inclosure. Code numbers appearing on figures and foldouts are for use by preparing agency only. If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to SAAS/TTOXU, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

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This volume is valued at 36 hours (12 points).

Material in this volume is technically accurate, adequate, and current as of December 1978.

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NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Linefinder Equipment

IN VOLUME 2 we discussed a manual telephone system and its similarities to automatic telephone systems. In this volume and the next, we discuss the Strowger and XY automatic telephone systems.

You may remember that a normal switch train consists of a linefinder, selector(s), and connector. Since the beginning is normally the best place to start and that is where the linefinder is, this chapter deals with the linefinder.

Linefinders are two-motion stepping switches which step automatically in response to a demand for service. A demand for service is created when a subscriber goes off hook to operate a line relay. Unlike the other two-motion stepping switches (selectors and connectors), linefinders are not operated by dial pulses. Instead, they are operated and their stepping is controlled by a group of relays which, in proper sequence, automatically close the circuits that provide particular linefinder actions and which automatically open the same circuits when the associated linefinder actions are completed. These same group relays test the next linefinder, which is attached to the banks of the distributor, to determine whether it is idle or in use. When trouble occurs, the group relays also transfer all calls to the partner group relays.

Each linefinder is wired directly to one particular first selector, which returns dial tone to the calling subscriber. The selector also forwards calls through the central office. The linefinder begins every phone call. It is unique in that (1) it is fully automatic, and (2) it is not really as complicated as the schematic drawing (see FO 1 in the separate inclosure) makes it appear. In this chapter we will review the basics of linefinding.

1-1. Linefinder Description

The primary purpose of the linefinder is to provide each calling party that is connected to its line banks access to a trunk (interoffice) line for a selector switch. In the case of a small central office, it provides access to a connector switch.

400. Using figure 1-1 and foldout 1 as necessary, specify the purpose and use of Strowger linefinder equipment by identifying linefinder switch type and distributor purpose, how the linefinder connects to the next switch train switch, the number of windings the combined line and cutoff relay has and has joined to its operating circuit, the number of distributors used with each linefinder group in a selected shelf, what makes a linefinder operate, and how two group's linefinders are wired so efficient preferential hunting is achieved.

A linefinder shelf is normally equipped to service 200 lines at 10 percent trunking. This means that there are normally 20 linefinder switches per shelf. The linefinder shelves are divided into two groups (A and B). A typical shelf has 200 line-cutoff relays, two distributor switches, two group relays, and a fuse.

We have said that the action of a linefinder is not controlled by the telephone user's dial. Instead, when the calling party lifts the handset from the cradle, he places the battery on the linefinder control bank contact associated with the calling telephone. Other units on the shelf then raise the linefinder and rotate its wipers automatically until they reach that marked contact. Under control of the group relays and the distributor, the linefinder extends the loop of the calling telephone to the associated selector or connector. The distributor preselects a linefinder for an originated call. The line relay of the calling line marks one of the linefinder's control bank contacts with negative battery to indicate which line is originating the call, and marks one of the linefinder's vertical bank contacts with ground to indicate the bank level of the line appearance. The group relays control the vertical and rotary stepping until the linefinder wipers find the marked contact.

The linefinder performs the following functions:

a. It steps its wipers up to the level marked on the vertical bank.

b. It rotates its wipers onto the bank contacts of the calling line.

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c. It connects its associated selector to the calling line loop.

d. It operates the two-step combined line and cutoff relay of the calling line and removes the line relay winding from the loop, and it also places the ground on the CN lead to the connector.

e. It makes the calling line busy at its multiple connector bank contact.

f. It causes the distributor to assign an idle linefinder for the next call.

g. It releases when the call is ended.

The following equipment, along with the linefinder, makes up a linefinder shelf: line and cutoff relay, distributors, group relays, and linefinder control relays.

Line and Cutoff Relay. One combined line and cutoff relay, figure 1-1, (usually called the line relay) is provided on the linefinder shelf for each telephone line to be served. The manufacturer frequently refers to this relay as line equipment, because in earlier times, two or three relays were required to perform the functions now handled by one relay. In a central office, line relays are usually assembled on mounting bases in groups of 20 or 40.

As its full name implies, the line and cutoff relay has two functions: (1) line relay and (2) cutoff relay.

Line relay. In its first-step operation, the line and cutoff relay functions as a line relay when the handset of the related line is removed from its cradle. At this time, the three windings of the relay are in series and are bridged across the telephone line. The current through the windings develops a magnetic field strong enough to close the relay's make (X) contacts, but not strong enough to open the break contacts. Closing the make (X) contacts places ground at a specific level on the vertical bank and connects negative battery to a control bank contact on that same level. This relay action closes a loop circuit to the group relays. These group relays then complete the circuit, which starts the linefinder searching for the marked line.

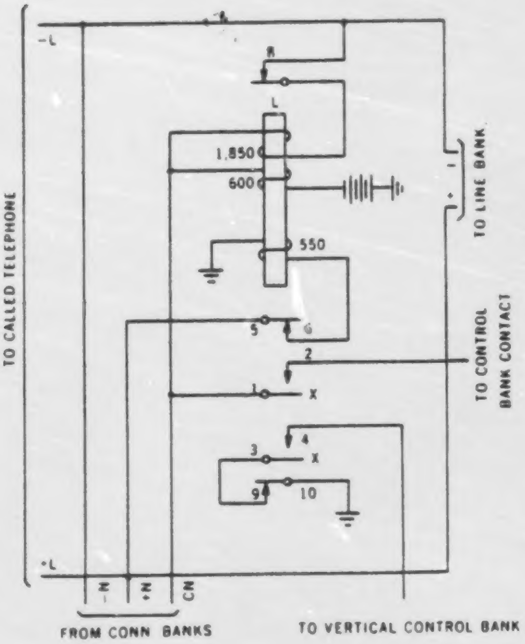

Figure 1-1. Line and cutoff relay.

Cutoff relay. In its second-step operation, the relay has a cutoff function. It frees its windings from the loop and releases the group relays and distributor after the linefinder completes a connection through to the selector. In its second-step operation, only the 600-ohm winding is connected across the central office battery. Thus the current increases, and the relay operates fully to open its three pairs of break contacts.

The cutoff function also occurs on incoming calls when a connector seizes the line. This connector seizure removes the bridged line relay coils from the line and prevents a linefinder from starting to search following removal of the receiver when answering a call.

Distributor. You have seen that the linefinders on the shelf are divided into two groups and that each group is under control of the distributor. This 25-point rotary stepping switch connects the group relays to any one of the linefinders of its group. This distributor also disconnects from the linefinder just as soon as it has seized the calling line. The distributor also assigns for the next line to follow.

Group Relays. Each group of linefinders is related to a set of group relays. These group relays are not to be confused with the linefinder switch control relays. These relays start the linefinder assigned for the call to operating and provide a pulsing circuit for operating the vertical magnet. These group relays stop the vertical stepping of the linefinder when its vertical wiper engages the marked vertical bank contact of the level on which the calling line is located. These relays also operate a pulsing circuit for the rotary magnet of the linefinder and release the distributor from the linefinder when the calling line is seized. They also transfer the call to the partner group of linefinders if the assigned linefinder fails to find the calling line or if all the linefinders in the first group are busy.

The group relays of the 200-point linefinder, shown in foldout 1, are listed below:

A3 - Pulsing
B3 - Timing
C3 - Group Relay Start
D3 - Transfer (vertical to rotary stepping)
E3 - Trouble Transfer Primary
F3 - Secondary
G3 - Release
H3 - Trouble Transfer Secondary
J3 - Primary Cut-Through Lower Bank
K3 - Primary Cut-Through Upper Bank

N3 - Normal Transfer
P3 - Control

Linefinder Control Relays. Each linefinder contains these three relays:

B - Linefinder Start
A - Cut-through Upper Bank
D - Cut-through Lower Bank

Preferential Hunting. If a linefinder were required to search for calling lines on all 10 levels of its banks, lines that appear in the lower levels would probably be the first to get that linefinder. To prevent this, a system of preferential hunting was devised.

The theory of preferential hunting is as follows: If a linefinder has to search for lines in its lower five banks only, hunting time is reduced considerably; and there is little danger of lines in the lower bank levels stealing a linefinder from lines in the upper five levels. The linefinders on the shelf are, therefore, divided into two groups, A and B, each with its own distributor and group relays. The linefinders in group A have lines connected to their banks in the regular numerical sequence previously described. The linefinders in group B have the levels reversed from top to bottom. For example, if in group A a line appears in level 3, it will appear in level 8 of group B, as figure 1-2 illustrates. Under normal operating conditions, therefore, the linefinders of both groups (A and B) are prevented from searching for calling lines above the fifth level. Each group thus serves half the lines; but in the event of equipment failure or if there is too much traffic in one group, the extra traffic is transferred to the partner group, and the partner group is allowed to search in all 10 levels. Lines with the same numbers are multipled throughout all linefinders of both groups. For example, line 33 will appear on line bank contacts numbered 33 in both groups even though their physical location in group A is different from that in group B.

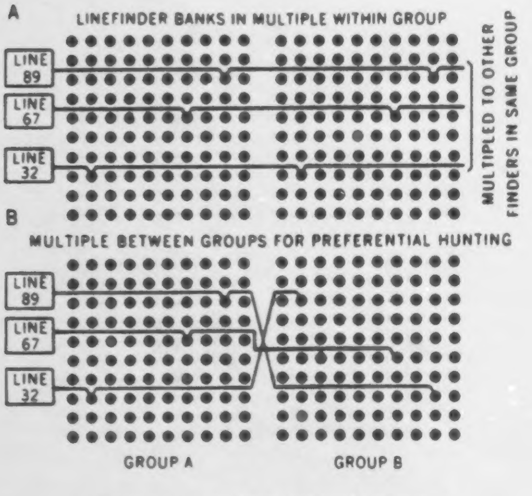
A
LINEFINDER BANKS IN MULTIPLE WITHIN GROUP
LINE 89
LINE 67
LINE 32
MULTIPLED TO OTHER FINDERS IN SAME GROUP
B
MULTIPLE BETWEEN GROUPS FOR PREFERENTIAL HUNTING
LINE 89
LINE 67
LINE 32
GROUP A
GROUP B

Figure 1-2. Linefinder bank multipling.

In telephone language, the linefinder banks within each group are multipled straight, and between linefinder groups the banks are multipled in reverse.

The +, −, and C wipers of the linefinder are permanently connected to the connectors. These are also connected to a selector or connector, thus forming a linefinder-selector link or a linefinder-connector link. The linefinder, group relay, and distributor circuits of group A are identical to those of group B.

Exercises (400):

1. What type of switch is the linefinder?
2. How is the linefinder connected to the next switch in the switch train?
3. What causes a linefinder to operate?
4. How many windings does the combined line and cutoff relay have, and how many are connected in its operating circuit?
5. What is the purpose of the distributor?
6. When does the distributor step?
7. How many distributors are used with each group of linefinders in a given shelf?
8. How are the linefinders in two groups wired in order that preferential hunting will be accomplished efficiently?

1-2. Linefinder Circuit Operation

The linefinder circuit of the typical step-by-step dial central office is composed of the four following groups of equipment: (1) line relays, (2) linefinders, (3) group relays, and (4) distributor equipment.

401. Using figure 1-1 and foldout 1 and given all linefinder shelf equipment functions, identify as

necessary each piece of equipment by name, list the Strowger distributor bank levels, and compare the distributor and the rotary line switch.

Although the line relays and linefinders are separate units, they operate in unison and are, therefore, grouped together under the single term "linefinder" equipment. Because the group relays and the distributor likewise function together, they are referred to as group-distributor equipment. The linefinder equipment and the group-distributor equipment operate with each other in seeking out a calling line and connecting it to an idle trunk leading to a selector or to a connector. The combined line and cutoff relay (generally shortened to line relay), shown in figure 1-1 and the upper center of foldout 1, is connected to one telephone only. As we have explained previously, each of the telephone lines served by a linefinder has its own line relay. The operation of the line relay of any telephone line depends upon whether the call originates or terminates in that line; that is, whether the call is outgoing or incoming. A number of linefinders are grouped under the control of a single distributor. The group relays are 12 relays mounted on a separate base. One set of these group relays is connected to each group of linefinders. The group relays control the operation of the linefinders. They also cause the distributor to operate. One distributor is common to each group of linefinders. It distributes all calls which come from its individual group over all of the linefinders included in the group. The distributor is a 25-point, non-homing-type rotary stepping switch. It has a bank of five levels, with 25 contacts on each level. The distributor has six pairs of double-ended wipers—one set for each of the six distributor bank levels. The levels of the distributor bank are marked as follows:

LEV A, Guard
LEV B, Finder Start
LEV C, Vertical Stepping
LEV D, Test 1 for Vertical Level
LEV E, Lower Bank Cut-Through
LEV F, Upper Bank Cut-Through

The various levels of the distributor switch are illustrated schematically in the center of foldout 1. The distributor wipers are shown in contact with only one of the 25 sets of bank contacts of the 6-level distributor switch. The wipers may be stepped to any of the 24 other positions on the distributor bank. Each position controls a single linefinder. The 25-point rotary stepping switch, used here as a distributor, may also be used as a rotary line switch, except that the rotary line switch has only three bank levels and three double-ended wipers.

The 200-point linefinder circuit shown in foldout 1 is a two-motion stepping switch.

The vertical bank is shown as a row of 11 contacts. Ten of the contacts serve the ten bank levels, and the eleventh is the dead contact on which the vertical wiper rests when in the unoperated position.

The combined line and cutoff relay in operating its X (first-step) contacts electrically marks the vertical bank contact of the level in which a calling line is located. The vertical bank and vertical wiper permit the linefinder to step its +, −, and C wipers, all at the same time, to the proper bank level of a calling line without having to test the individual contacts of the other line bank levels.

Exercises (401):

1. Identify the 25-point non-homing-type rotary stepping switch.

2. List the Strowger distributor bank levels.

3. Compare the distributor and the rotary line switch.

4. Identify the Strowger equipment which connects the calling telephone to the first central office equipment unit.

5. Name the Strowger equipment which connects the calling telephone to an idle selector trunk.

6. Name the Strowger equipment that controls a group of linefinders.

Although the operation of the linefinder is simple, the schematic diagram appears somewhat complicated because of the number of circuits involved. In the following paragraphs, we shall discuss in detail each of the simple, direct-current circuits shown on the schematic of foldout 1 in the order in which they operate. The individual relays are shown in their normal (unoperated) condition, except relay N3, which is normally operated. When tracing these linefinder circuits, you must visualize the condition of each relay at any given instant during the sequence.

We are going to look at the following steps in the linefinder circuit operation: seizure and vertical stepping, rotary stepping and cut-through, and release.

402. Using foldout 1's schematic diagram, identify the actions that occur in the linefinder equipment during seizure and vertical stepping and state the effects these actions have on associated equipment.

Seizure and Vertical Stepping. When a linefinder shelf is installed, connected, and ready for operation, the circuit through relay N3 is complete. Therefore, relay N3 remains operated constantly, except during periods of very heavy traffic.

If, at this time, you do not have foldout 1 opened up in front of you, the following discussion won't mean much. The circuit which holds N3 operated, before the operation of a linefinder in its group, may be traced on foldout 1 as follows:

From battery, trace through the N3 relay windings, through contacts of relay E3 and the group busying switch (SW-7) of the group relays, contacts of the VON switch (SW-1), the linefinder busying switch (SW-6), and through the B relay to ground.

Since the ATB GND lead is multipled with the VON switches (SW-1) of all the linefinders in a group, when one or more linefinders in a group are idle (its VON switch is not operated), relay N3 remains operated.

Relay L. (Operated: Relay N3.) When a calling party removes the handset from the cradle, he completes a circuit through the windings of relay L. Again, the magnetic field developed by the current through these three windings is only strong enough to close the X contacts of relay L (contacts 1, 2, 3, and 4). Trace this path and all others on the foldout as we progress.

(1) "X" contacts 1 and 2 close the path that places 600 ohm negative battery on the control bank contact to stop rotary stepping of the linefinder.

(2) "X" contacts 3 and 4 close the operating path, through a level marking resistor, for relay C3.

Relay C3. (Operated: Relay N3 and X contacts of relay L).

(1) Contacts 1 and 2 close a circuit through the LF start signal lamp, but the lamp will not light unless relay C3 remains operated for between 9.5 to 19.5 seconds.

(2) Contacts 3 and 4 close the operating path for the P3 relay. The path for relay P3 starts with ground at contacts 4 and 5 of relay F3 and goes to battery through the windings of the motor magnets. The motor magnets will not operate in series with the P3 relay.

Relay P3. (Operated: Relays N3, C3 and X contacts of relay L).

(1) Contacts 4T and 5T close the operating path of the B relay in the linefinder, through level B of the distributor.

(2) Contacts 4B and 5B close the operating path for relay B3.

NOTE: Relay B of the linefinder and relay B3 of the group relays operate immediately after P3. Each relay starts a separate series of relay operations, but both relays operate at the same time. Relay B starts the relay action for vertical and rotary stepping of the linefinder, and relay B3 starts a timing circuit which causes the call to be transferred to the partner group of linefinders if the linefinder fails to function properly. It is important to remember that the two operations take place at the same time.

(3) Relay P3 partially completes a circuit to ground from its own winding through contacts 7T and 6T to contact 6 of relay F3.

(4) Relay P3 provides an additional circuit to ground for the winding of relay N3 through contacts 2B and 3B of relay P3. This circuit is required only when a linefinder is the last in its group to operate. In this event, when relay B of the linefinder operates, it removes the only remaining circuit to ground from the winding of N3 through the ATB GND lead. This additional ground holds relay N3 operated until the call is completed, after which relay N3 is restored.

(5) Relay P3 partially completes the circuit which stops vertical motion when the vertical bank wiper reaches the marked vertical bank contact. This circuit is completed when the vertical wiper seizes the marked vertical contact.

(6) Relay P3 partially completes the circuit for the VERT MGT.

Relay B3. (Operated: Relays N3, C3, and P3, and the X contacts of relay L.) The discussion in later paragraphs describes the action of the group relays and linefinder relays in extending the loop to the selector. Immediately following the operation of relay P3, a sequence of relay operations, beginning with relay B3, is started.

This sequence of relay actions serves as a timing device which controls the operating time of the linefinder. Relay B3 closes the operating circuit of relay H3.

Relay H3. (Operated: Relays N3, C3, P3, and B3, and the X contacts of relay L.) Relay H3 partly completes its own holding circuit. Relay H3 also performs the following functions:

(1) Contacts 10 and 11 close a circuit which applies ground potential to the fifth level of all linefinders in its own group, thus preventing the linefinder from operating above the fifth level until H3 or N3 of the opposite group restores.

(2) Contacts 5 and 4 close the operating path for relay F-3.

(3) Contacts 1 and 2 open a partially completed circuit to relay E3 to prevent relay E3 from operating when relay F3 operates.

Relay F3. (Operated: Relays N3, C3, P3, B3, and H3, and the X contacts of relay L.) Relay F3 operates when relay H3 completes its operating circuit as stated earlier. Relay F3 performs the following functions:

(1) It completes its own holding circuit through the 1250-ohm winding.

(2) Relay F3 opens the initial operating circuit of relay P3. This circuit was completed through contacts 4 and 5 of relay F3 when F3 was not operated.

(3) Relay F3 completes another circuit to ground for relay P3 through contacts 6T and 7T of relay P3.

(4) Relay F3 opens the operating circuit of relay B3, which passes through contacts 1 and 2 of relay F3 when F3 is not operated.

(5) F3 also partially completes the operating circuit of relays K3 or J3, which passes through contacts 7 and 8 or 9 and 10 of relay F3 (FO 1).

Relay B3 restores. (Operated: Relays N3, C3, P3, B3, H3, and F3, and the X contacts of relay L.) When relay B3 restores, it starts its weighted armature vibrating. The armature makes alternate contact with the two points of contacts 2 and 4 of relay B3, thus they continue to complete the circuit which holds relay H3 operated. This effect is possible, because relay H3 releases slowly. The contacts of relay B3 are set to vibrate long enough to keep the holding circuit for a period of approximately 3½ seconds. Under normal conditions, the linefinder will operate, seize the marked contact, and extend the loop of the calling telephone to the selector in this time interval.

NOTE: In the sequence of relay operation described in the preceding paragraphs, we have assumed normal operation of the linefinder up to and including the actual extension of the loop to the selector.

Relay B. (Operated: Relays N3, C3, and P3, and the X contacts of relay L.) Relay P3 completes the operating circuit of relay B.

When relay B operates, it opens, completes, or partially completes the following circuits:

(1) It completes the operating circuit of the VERT MGT through contacts 10 and 11.

NOTE: The VERT MGT circuit was partially completed to contact 10 during operation of relay P3.

(2) Relay B partially completes the operating circuit of the RTY MGT.

(3) Relay B opens (at its contacts 3 and 4) the circuit which held relay N3 operated before the call was started. N3 does not restore, because an additional circuit has been provided through contacts 2B and 3B of relay P3. When contact 4 of relay B breaks with contact 3, it makes with contact 5, thereby partly completing a circuit to the selector over the C lead by placing ground potential on the C lead.

(4) Relay B opens (at its contacts 1 and 2) the circuit from the GUARD lead to ground, which will be completed when the VON switch operates if contacts 1 and 2 of relay B are not opened. Opening contacts 1 and 2 prevents grounding of the GUARD lead at this point in the sequence. A grounded GUARD lead will cause the distributor wipers to step off the distributor contacts associated with the operating linefinder and disconnect it from the group relays.

(5) Relay B places the 500-ohm noninductive winding of relay D across the loop to the first selector by closing contacts 12 and 13. This action preseizes the selector and means that the calling party receives dial tone faster.

Vertical magnets. (Operated: Relays N3, C3, P3, and B, and the X contacts of relay L.) When relay B operates, it completes the operating circuit of the VERT MGT. When the VERT MGT operates, it raises the wiper assembly one step and completes the operating circuit of relay A3.

VON switch. (Operated: Relays N3, C3, P3, and B, the X contacts of relay L, and the VERT MGT.) The mechanical movement of the linefinder switch caused by the first operation of the VERT MGT operates the VON switch SW-1. The VON switch contains two sets of break-before-make contacts. When the switch is not operated (the linefinder is in its idle position), the C lead to the selector is connected to the GUARD lead of the linefinder. If a short occurs in the trunk between the first selector and the linefinder, a circuit is completed from the GUARD lead of the linefinder to ground. This also occurs if the selector fails to remove ground from the C lead as a result of improper operation. If this occurs, the distributor wipers find the linefinder marked "busy" and step past it to the next idle linefinder. When a linefinder is seized and operated, contacts 5 and 6 of the VON switch complete this guard circuit. A circuit to ground from the winding of relay N3 is completed through contacts 2 and 3 of the VON switch when it is not operated. This circuit passes through the ATB GND lead, which is multipled to contact 3 of the VON switches of all linefinders in the group. Therefore, if the operating linefinder is the last in a group to operate, the circuit to ground from the winding of relay N3 is broken; and N3 restores if it was not being held operated by the ground from contacts 2B and 3B of relay P3. The VON switch also completes a connection to ground through its contact 4 and 5, which is used by several circuits during the operation of the linefinder. The VON switch will also close its contacts 1 and 2 through which the operating circuit of the RLS MGT is completed when the call has been fully completed.

Relay A3. (Operated: Relays N3, C3, P3, and B, the X contacts of relay L, the VERT MGT, and the VON switch.) The operating circuit of relay A3 is completed by operation of the VERT MGT and its interrupters (SW-2).

When relay A3 operates, it opens its break contacts 2 and 3, thus opening the operating circuit of the VERT MGT. Consequently, the VERT MGT restores. But when relay A3 restores, it again completes the operating circuit of the VERT MGT, and the VERT MGT operates. Each time the VERT MGT operates, the wiper assembly is raised one step. This alternate operation of relay A3 and the VERT MGT continues until the vertical bank wiper reaches the marked vertical bank contact.

Relay D3. (Operated: Relays N3, C3, P3, and B, the X contacts of relay L, and the VERT MGT.) When the vertical wiper reaches the marked vertical bank contact, a circuit through the 85-ohm winding of relay

D3 is completed. A3 operates and holds momentarily, because its operating circuit is in series with the 85-ohm winding of D3.

Relay D3 in full operation. (Operated: Relays N3, C3, P3, B, A3, H3, and F3, the X contacts of relay L, and the X contacts of relay D3.) Operation of H3 and F3 occurs at the same time as vertical and rotary stepping. It may also be noted that the contacts of relay B3 will be vibrating at this stage of the sequence. When relay D3 closes its X contacts, it completes a circuit through its 650-ohm winding, which operates D3 fully. The operated relay D3 completes, partly completes, or opens the following circuits:

(1) It opens the operating circuit of the VERT MGT at contacts 3 and 4.

(2) Relay D3 opens the operating circuit of A3 by causing the VERT MGT to restore.

(3) Relay D3 completes the RTY MGT circuit.

(4) Relay D3 fully operated opens the circuit through its 85-ohm winding at contacts 6 and 7.

(5) Relay D3 opens the initial operating circuit of relay P3, which is completed through its contacts 9 and 10. NOTE: When D3 opens the circuit to the VERT MGT, the VERT MGT restores; consequently, A3 restores.

Exercises (402):

Complete the following items relative to linefinder equipment during seizure and vertical stepping, using foldout 1 as necessary:

1. What relays make up the timing circuit in the group relays?

2. What is the purpose of the vertical interrupter springs in the linefinder?

3. What relay in the group relays is normally operated? Why?

4. Which relay contacts in the group relays close the operating path for the D3 relay?

5. List the circuit operations that occur immediately due to the operation of relay C3.

6. State why the linefinder, when line relay 41 operates, does not stop on the first vertical level.

7. Why is the selector preseized? How?

8. Why doesn't the LF start signal lamp light when relay C3 first operates?

9. If the N3 relays are not operated when a subscriber goes off hook, what action results in the linefinder equipment?

403. Using foldout 1 as necessary, identify the actions that occur in the linefinder equipment during rotary stepping and switch-through and state the effects these actions have on associated equipment.

Rotary Stepping and Switch-Through. Let's quickly review what we have covered: The subscriber went off hook, closing the loop to operate a line relay. The line relay marked the vertical bank with ground and closed the operating path for relay C3. The C3 closed the operating path to the P3 relay, which caused actions in the linefinder, as well as in the group relays. The P3 relay started the timing circuit in the group relays and closed the operating path of the B relay in the linefinder. The B relay closed a path for preseizure of the associated selector and to the vertical magnets in the linefinder. The vertical interrupter springs of the linefinder and relay A3 of the group relays worked in conjunction to step the linefinder vertically to the proper level.

Now let's cover the linefinder stepping rotary.

Rotary magnet. (Operated: X contacts of relay L and relays N3, C3, P3, B, H3, F3, and D3.) When relay A3 restores, it completes the circuit to the RTY MGT by closing its own 3 and 2 contacts. When the rotary magnet operates, it completes the operating circuit of relay A3. The operating circuit for relay A3, which was completed to ground through contacts 1 and 2 of the VERT MGT, is now completed to ground through contacts 1 and 2 of the RTY MGT. (Note that the VERT MGT has completed its function and restores.) When A3 operates, it opens the operating circuit of the RTY MGT. Thus, the RTY MGT restores. But when the RTY MGT restores, it opens the operating circuit of A3. A3 restores and again completes the operating circuit of the RTY MGT. The alternate operation of the RTY MGT and relay A3 will continue, moving the linefinder wipers one rotary step for each operation of the RTY MGT until the wipers reach the marked contact of the control bank.

We now need to stop and look at something. We said earlier that we had cut-through relays for the upper and lower banks in both the linefinder and the group relays circuits. The J3 and K3 relays in group relays work in conjunction with A and D relays in the linefinder. The A and K3 relays and the D and J3 (disc jockey may help you remember) relays work together. The A relay is for upper bank, and the D, for lower bank selection. For our purpose our calling party is in the lower bank.

Operation of Relay J3, and full operation of relay L. (Operated: Relays N3, C3, D3, P3, H3, and F3, and X contacts of relay L, and the RTY MGT.) If the control bank contact is electrically marked with negative battery, the operating circuit of relay J3 is completed.

(1) The operating circuit of the RTY MGT is opened when relay J3 operates, because it is completed through contacts 1 and 2 of this relay. Therefore, when relay J3 operates, the RTY MGT restores. (Note that when the RTY MGT operates for the last step, it closes the circuit of relay A3. Therefore, relay A3 operates and then it restores. This has no effect on the other parts of the circuit.)

(2) The operating circuit of relay J3 is completed through the 600-ohm winding and contacts 1 and 2 of relay L. Thus, relay L operates fully. Full operation of relay L removes the line relay windings from the loop circuit and removes ground from the CN lead to the connector (FO 1). Ground is replaced on the CN lead by the selector when relay D operates.

(3) Full operation of line relay L also opens the first operating circuit of relay C3, which was completed through the 9 and 10 contacts of relay L to ground. C3 does not restore, however, because of a holding circuit completed through contacts 10 and 11 of operated relay H3.

Relay D. (Operated: Relays N3, C3, P3, B, D3, H3, F3, and J3.) Since the control bank wiper is marked, relays J3 and D operate. Relay D circuit is completed through contacts 3 and 4 of relay J3. The operating circuit of relay D also includes the make contacts 4 and 5 of operated relay D3. Since relay D3 is one of the group relays, it will restore after the linefinder has extended the loop of the calling telephone to the selector or connector; but relay D must remain operated for the duration of the call. Therefore, when relay D operates, it completes its own holding circuit through its 4T and 5T contacts. Ground potential is kept on the C lead during the progress of the call by each switch, one after another, and finally by the connector. When relay D operates, it also completes or opens the following circuits:

(1) It extends the + and − lines of the calling telephone loop to the selector through contacts 7B-8B and 5B-6B, respectively.

(2) It completes a circuit through the 600-ohm winding of relay L and through contacts of the related selector or connector to ground.

(3) It completes the operating circuit of the distributor MM. Prior to the operation of relay D, the circuit from the distributor level A to ground was open.

(4) It opens (at relay D contacts 1T and 2T) a partially completed circuit through the RLS MGT.

(5) It opens the circuit to the RTY MGT at contacts 3B and 4B.

Distributor motor magnet operates. (This happens right after the operation of relay D. The following relays are operated at this point: relays N3, L, C3, P3, B, J3, D, H3, F3, and D3.) The VERT MGT, relay A3, and the RTY MGT have restored. Relay B3 has restored, but its armature will be vibrating. When relay D operates, it completes a circuit through the winding of the distributor MM as described above. When MM operates, it opens the circuit between relay P3 and negative battery at its interrupter springs 1 and 2.

Relay P3 restores. (Operated: Relays N3, L, C3, H3, D3, D, J3, and F3.) As relay P3 restores, it opens the MM circuit by breaking contacts 2T and 3T. The closing contacts 1T and 2T of relay P3 partially complete another circuit through the winding of the MM. When relay P3 restores, it also opens the following circuits:

(1) It opens the operating circuit of relay B, which is completed through contacts 4T and 5T of relay P3. Hence, relay B restores. Also, the operating circuit of relay D3 is opened at contacts 5B and 4B of relay P3.

(2) It opens the operating circuit of relay H3, which is completed through contacts 4B and 5B of P3.

(3) It opens a circuit from ground to the winding of relay N3, which is completed through contacts 2B and 3B of relay P3. Note, however, that relay N3 may not always restore, since its circuit is completed through the ATB GND lead, which is multipled to ground through the VON switch and through unoperated contacts 3 and 4 of relay B of any idle linefinder in its group. If, however, the operating linefinder is the last of its group which is idle when the call is cut through to the selector, the holding circuit of relay N3 will be opened when contacts 2B and 3B of P3 break; then, N3 will restore.

(4) It further opens the operating circuit of relay A3 by breaking contacts 8T and 9T (FO 1). Since the circuit of relay A3 was opened when the vertical and rotary stepping was completed, this contact opening has no further effect on the circuit.

(5) It also opens the D3 relay X contact circuit. This circuit was previously broken when D3 fully operated; therefore, this contact opening also has no effect on the circuit.

Distributor MM restores. When relay P3 restores, it opens the operating circuit of MM. As MM restores, it causes the distributor wipers to rotate one step, and at the same time, it closes its interrupter contacts. When the distributor moves forward one step, it breaks the following circuits between the group relays and the linefinder, which has just completed the operation, and partially completes the same circuits between the group relays and the linefinder related to the next set of distributor contacts:

(1) In restoring, distributor level B breaks the

operating circuit of relay B of the linefinder. (Note that relay B actually restores when P3 restores.)

(2) When MM restores, it closes its interrupter contacts 1 and 2. This may or may not complete a circuit through the winding of MM.

If the linefinder to which the wipers have stepped is idle, its A or D and B relays will restore to open the circuit connection to the C lead. Consequently, MM does not operate again, and the distributor wipers remain on the distributor contacts of tnis idle linefinder. If the linefinder to which the wipers have stepped is busy, the circuit will be complete from contacts 3 and 4 of the busying switch to contacts 8T and 9T, relay D, or 7T and 8T of relay A. If the linefinder is idle, the distributor wipers remain on the linefinder's distributor contacts. If the linefinder is busy, the wipers are stepped forward by the operation and restore MM, as already described. Thus, the distributor will continue to step its wipers from linefinder to linefinder until an idle one is found, provided that at least one linefinder in the group is idle.

(3) Distributor level C opens the VERTICAL lead over which the circuit to the VERT MGT is completed.

(4) Distributor level E opens the lead to relay D of the linefinder over which the initial operating circuit of relay D is completed. Relay D provides its own holding circuit.

(5) Distributor level F opens the lead to relay A of the linefinder over which the initial operating circuit of relay A is completed. Relay A, like relay D, provides its own holding circuit.

(6) Distributor level D also opens the TEST lead over which the circuit to relay J3 is completed.

Relay B of the linefinder restores. (Operated: Relays N3, L, C3, H3, D3, F3, and D.) In studying this section, note that a number of relays release at the instant relay B restores. When relay B restores, it completes the following functions:

(1) It opens the operating circuits of the VERT MGT and RTY MGT, which are completed through relay B contacts 10 and 11 and contacts 8 and 9. These circuits were already open at other connection points.

(2) It completes a multiple circuit to ground from the guard lead, level A of the distributor. The function of this circuit is to mark the distributor contacts as busy until the call is ended (until the linefinder restores its VON switch).

(3) It opens the circuit which first connected ground potential to the C lead. This circuit is completed from the C lead through contacts 4 and 5 of relay B to ground (FO 1). Note, however, that ground is applied to the C lead by the next switch in the train (selector or connector) as soon as relay D or A operates. When contact 4 breaks with contact 5, it makes with contact 3, thus partly completing the circuit to the RLS MGT.

(4) It removes the 500-ohm, noninductive shunt winding of relay D from the line loop by opening contacts 12 and 13.

Relay H3 restores. (Operated: Relays N3, L, C3, D3, F3, D, and J3.) Relay H3 restores when its holding circuit is opened by the release of relay P3. When relay H3 restores, the following things happen:

(1) It opens contacts 10 and 11 to disconnect the holding circuit of relay C3.

(2) It opens contacts 8 and 9, through which its own holding circuit was completed before B3 restored.

(3) It opens contacts 2 and 3, through which the holding circuit of relay D3 was completed before P3 restored, and closes contacts 1 and 2, through which the operating circuit of relay E3 would have passed if relay P3 has not restored.

Relay D3 restores. (Operated at this point: Relays L, C3, D, and F3.) The release of relay D3, which happens right after the release of P3, has no effect on the group relay circuits or the linefinder, because all circuits completed through its contacts were already opened when other relays in the group were restored.

Relay C3 restores. (Operated: Relays L, D, and F3.) The holding circuit of relay C3 is opened when relay H3 restores. The restored relay C3 opens the circuit to the ST SIG lamp (FO 1), which is completed through contacts 1 and 2. The released C3 also opens contacts 3 and 4, which completed the initial operating circuit of P3 before F3 operated. If another call has been originated in the group relay, C3 will not restore as indicated. The second call will operate the line relay of the calling telephone. The line relay X contacts complete a circuit to relay C3 through the start and level marking resistors. This circuit, which prevents relay C3 from restoring, may or may not be completed through the same start and level marking resistor as the previous call. Although relay C3 remains operated, relay P3 cannot operate until relay F3 restores, because the initial operating circuit is completed through contacts 4 and 5 of relay F3 to ground. Since F3 is the last of the group relays to restore (except for C3), the group relays will be ready to handle the next call when F3 restores.

Relay F3 restores. (Operated: Relay L and relay D of the linefinder.) Relay F3 restores when its operating circuit is opened by H3. The release of relay F3 has no effect on the circuits of either the group relays or the relays of the linefinder, because all circuits completed through its contacts were opened by the release of other relays.

All group relays restored. As each group relay restores after the loop is extended to the selector, its contacts return to the position held at the start of the call. When all group relays have restored except N3, they are ready to handle another call through the linefinder to which they have been connected by the distributor. Relay D of the linefinder (which has operated) and the line relay L do not restore until the calling party places the handset on the cradle. Note, however, that the linefinder which we have discussed throughout this chapter is no longer connected to the group relays, because the distributor wiper has stepped to the next linefinder.

Exercises (403):

Complete the following items relative to linefinder equipment during rotary stepping and cut-through, using foldout 1 as necessary.

1. What prevents the line relay from operating the linefinder when the called party picks up the handset to answer the telephone?

2. What relay(s) in the linefinder equipment is/are held operated during conversation?

3. How do the actions of relay A3 affect the group relays and linefinder during rotary stepping?

4. Specify the actions of the linefinder equipment if the next linefinder, connected to the banks of the distributor, is not idle.

404. Using foldout 1 as necessary, identify the actions that occur in the linefinder equipment during release and transfer.

Release and Transfer. When the calling party replaces the handset on the cradle, the loop circuit is open to the last switch in the train. This switch will be the connector if the call has been extended to the connector, but it will be the selector if the calling party replaces the handset before the loop is extended to a connector. When the loop circuit is open, relay B of the last switch in the train restores to remove ground from the C lead.

Relays D and L restore. The circuit that holds relays D and L operated is grounded through the C lead. When the last switch in the train removes this ground, the relays restore.

Relay G3 and RLS MGT operate. When relay D restores, it completes a circuit from negative battery through the winding of relay G3, through the RLS BATT lead of the RLS MGT, to ground at contacts 3 and 4 of relay B. When the RLS MGT operates, the movement of its armature withdraws detents from the vertical and rotary ratchets on the linefinder shaft. The tension on the shaft spring returns the shaft and bank wipers to the normal rotary position. When the shaft is in this position, a channel in the vertical ratchet permits the shaft to drop by its own weight to its normal vertical position. When relay G3 operates, it applies ground potential to the RLS lamp lead through contacts 1 and 2 and partially completes a circuit to the RLS alarm. If the switch fails to return to normal within a certain period of time, a delayed relay cycle sounds a buzzer at the power board and operates the signal group lamp (aisle pilot lamp) for a row of linefinder bays and the green RLS lamp on the fuse alarm panel of the particular shelf.

VON switch restores, and then relay G3 and the RLS MGT restore. (Operated: Relay G3 and RLS MGT.) When the linefinder shaft drops to its normal position, the VON switch restores to open contacts 1 and 2 (through which the circuit to the RLS MGT and relay G3 was completed). This restores the RLS MGT and relay G3.

If the linefinder wipers are prevented from stepping to the marked contacts of the calling line within the time allowed, the call will be transferred to the partner group of linefinders.

Relay B3 times out. The distance that the vibrating reed of relay B3 moves is slowly reduced before the reed comes to rest. The holding circuit of relay H3 is completed through the vibrating reed contacts of relay B3. As the vibrations of the reed decrease, relay H3 receives fewer pulses and is finally allowed to restore.

Relay H3 restores. (Operated: Relays N3, C3, P3, B, and F3, and the X contacts of relay L.) Relay D3 may or may not be operated, depending upon whether the movement of the linefinder is halted before or after rotary motion began. When relay H3 restores, it performs the following operations:

(1) It opens the circuit to ground from the 1300-ohm start winding of relay F3; but F3 does not restore, because it is held operated by current through its 1250-ohm winding.

(2) It opens the holding circuit of relay C3, which is completed through contacts 6 and 7. Relay C3 does not restore, however, because its initial operating circuit has not been opened. Note that the holding circuit for relay C3 also completes a circuit to ground from the fifth-level contact in the vertical bank of the linefinder in its own group. Whenever this fifth-level contact is marked with ground, the linefinders in that group will not operate above the fifth level. Since the TEST lead contacts ground on the fifth level, it completes the operating circuit for relay D3 and starts rotary motion.

(3) It completes the operating circuit of relay E3 while relay F3 is operated.

(4) As relay H3 releases, it also opens the holding circuit of relay D3 at contacts 3 and 2.

Relay D3 restores. (Operated: X contacts of relay L, and relays N3, C3, P3, B and F3.) If relay D3 was operated when relay H3 restored, D3 also restores. Release of D3 opens the circuit to the RTY MGT and the TEST lead, thus preventing rotary movement.

Relay E3 operates. (Operated: X contacts of relay L, and relays C3, P3, and F3.) When relay E3 operates, it remains operated by a circuit through its 1800-ohm winding to the ATB GND B lead and to the partner group of linefinders. Note that the holding circuit of relay E3 is completed through any idle linefinder of the partner group. Therefore, relay E3 will not restore until all linefinders in the partner group are busy or until the group busying switch of either group is mechanically operated by attending personnel. When relay E3 is operated, it also completes, partly completes, or opens the following circuits:

(1) It opens (at its contacts 3 and 4) the operating circuit of relay N3 in its own group. This circuit may be traced through contacts 3 and 4 of E3 and contacts 3 and 4 of the group busying switch (SW-7) to the ATB lead of its own group.

(2) It completes an operating circuit of the MM through contacts 5 and 6 of relay F3, 6T and 7T of relay P3, 8 and 7 of relay E3, 3T and 2T of relay P3, and through the coil of the motor magnet to battery.

Distributor MM operates. (Operated: X contacts of relay L, and relays C3, P3, B, N3, E3, and F3.) When MM operates, it opens its interrupter contacts to open the circuit between the winding of relay P3 and negative battery. Note that the circuit which operates the MM in this instance is not the same circuit which operated it during the normal sequence of linefinder operation.

Relay P3 restores. (Operated: X contacts of relay L, and relays B, C3, F3, E3, N3, and MM.) When MM operates, it opens the operating circuit of relay P3, which is completed through the interrupter contacts of MM. When relay P3 restores, it opens several circuits. Note, however, that some of the circuits completed through the P3 contacts were previously opened.

(1) At contacts 4T and 5T, it opens the operating circuit of relay B of the linefinder and the holding circuit of relay F3.

(2) At contacts 3B and 2B, it opens the holding circuit of relay N3.

Relay N3 restores. When relay N3 restores, it opens or completes the following circuits:

(1) It opens the operating circuit of relay C3 of its own group by breaking contacts 4 and 5 and closes a circuit through contacts 3 and 4 to relay C3 of the partner group (FO 1). Note that when any line relay operates, it marks the banks of all linefinders in both groups. Because of the arrangement of the start and level marking resistors, the circuit of relay C3 is normally completed only by operation of the line relays connected to the lower five bank levels of its own group of linefinders. When relay N3 restores, it opens the circuit between relay C3 and the start and level marking resistors of its own group and closes a circuit between relay C3 and the start and level marking resistors of the partner group.

(2) It opens contacts 8 and 9 of the circuit which mark the fifth-level contact in the vertical bank of the partner group, thus permitting the partner group to operate above the fifth level. When the circuit of the calling telephone is transferred to relay C3 of the partner group, the fifth-level marking circuit of the partner group is opened, and an idle linefinder of the partner group will search above its fifth bank level for the calling telephone.

(3) Contacts 6 and 7 open an operating circuit of the MM (which is normally closed through the interrupter contacts and the GUARD lead of a busy linefinder).

(4) It partially completes a circuit to the ATB meter (FO 1), which registers each time relay N3 of both groups is restored at the same time.

Relay C3 restores. (Operated: Relays P3, B, E3, and F3, and MM.) The initial operating circuit of C3 is completed through contacts 4 and 5 of relay N3. When N3 restores, it opens this operating circuit of C3 (FO 1). When relay C3 restores, it opens the following circuits:

(1) Contacts 1 and 2 open the circuit to the start signal lamp of its own group (FO 1).

(2) Contacts 3 and 4 further open the incomplete circuit for relay P3. The initial operating circuit of relay P3 received its ground through contacts 4 and 5 of relay F3, which is now operated. Therefore, open contacts 3 and 4 have no effect on the other parts of the circuit.

Distributor MM restores. (Operated: X contacts of relay L, and relay E3.) When distributor MM restores, it steps the wipers to the next set of distributor contacts. Although the interrupter contacts of MM close when it restores, a circuit is not completed over the GUARD lead if the linefinder to which the distributor wipers have stepped is busy. The circuit which normally keeps the distributor wipers stepping to an idle linefinder may be traced to contact 6 of relay N3, which has restored. The wipers of the distributor will, therefore, remain on the next set of distributor contacts until relay N3 of the group is again operated. Relay N3 will reoperate after relay E3 restores. When relay N3 reoperates, MM will resume its normal function and seize the first idle linefinder. Relay E3 remains operated until relay N3 of the B group releases or when SW-7 is operated manually.

A linefinder may fail to find the marked vertical bank contact, or it may seize the marked contact and start rotary motion but fail to find the marked control bank contact. If the vertical bank of a linefinder is marked on any level below the tenth and the linefinder fails to stop its vertical movement on reaching the marked contact, it will continue to step to the tenth level. Although no call has been originated in that level, the vertical bank contact on the tenth level is permanently grounded (FO 1) and will complete the rotary circuits.

If, during rotary stepping on any level, the control bank wipers fail to seize a marked contact, or if rotary stepping occurs across the tenth level when no line in that level is marked, the wipers will be stepped to the eleventh rotary position. When the wipers reach this eleventh rotary position, a cam mounted on the switch shaft directly under the rotary ratchet operates the cam switch SW-4, as foldout 1 reveals. When the cam switch operates, it closes a circuit from the GUARD lead to ground. This circuit may be traced from the GUARD LEADS THROUGH CONTACTS 3 and 4 of SW-6, and through contacts 1 and 2 of SW-4 to ground. When the GUARD lead is grounded, MM operates to start a series of relay operations. Notice that relays J3 and D are not operated, because the circuits to these relays are completed only when the wipers seize the marked contacts. Relays D3, F3, and A3, and the VERT MGT or RTY MGT may or may not be operated, depending upon the position of the wipers when failure occurs.

Relay N3 is held operated by a ground multipled through contacts 2 and 3 of the VON switch of each linefinder in its group. Each time relay P3 operates, it places a locking ground on relay N3 through contacts 2B and 3B. Locking ground is actually required only when the operating linefinder is the last of its group to operate.

When the linefinder starts vertical stepping, its VON switch operates. If the linefinder is the last of its group to operate, operation of its VON switch removes ground potential from the ATB GND lead through which the circuit of relay N3 is completed. The locking ground of relay N3, however, holds it operated until the loop has been extended to the selector and P3 has restored. When relay P3 restores, it removes the one remaining ground from the operating circuit of relay N3. Thus, it restores. When relay N3 restores, the start circuit is transferred to relay C3 of the partner group.

As soon as the loop of a calling telephone is extended to the first selector, ground from the linefinder control bank contact is applied over the CN (control normal) trunk wire and through the first selector to the connector bank contacts of that same telephone. This ground for the connector is kept there by each switch in the train as the loop is extended. If the calling telephone is called after the loop has been extended to the first selector, the grounded connector control bank contact sends a busy tone to the telephone of the party calling. If the calling line is free, the cut-through relay in its connector circuit will operate through the CN trunk wire to the 600-ohm winding of the line relay of the called telephone. This operates the line relay and prepares the called line for ringing.

Exercises (404):

Complete the following items relative to linefinder equipment during release and transfer, using foldout 1 as necessary.

1. State the electrical events that occur in the linefinder equipment when the calling party hangs up the phone.

2. What switch operates and what resulting actions occur when a linefinder steps to the eleventh rotary step on any vertical level?

3. How is the operating circuit of relay N3 connected through the VONS of each linefinder in a group? Why?

4. What prevents the distributor from stepping to an idle linefinder when the next linefinder connected to its banks is busy during trouble transfer? Why?

1-3. Troubleshooting the Linefinder

In Volume 2 of this course, we talked about a troubleshooting approach. We stop at this point, not to grind it into the ground, but to mention that we are now dealing with stepping switches. It is an unfortunate fact of life that many mechanical troubles appear to be electrical troubles. This happens not just to inexperienced tech school graduates, but to old heads as well. What was discussed in Volume 2 is still true. Troubleshooting must be systematic and follow a logical course if it is going to be quality troubleshooting and not a hit-or-miss proposition. A good knowledge of how the equipment works and an analysis of the symptoms will save much time and effort.

405. Given linefinder equipment trouble symptoms and using the schematic diagrams in foldout 1, identify the probable causes of trouble and state the corrective action for each.

Mechanical troubles mimicking electrical troubles are an age-old problem and will probably continue to be. Unfortunately, there are no particular rules to help you. It's a "feel" or instinct which is developed through experience. Helical springs with too much tension will often lead you to believe that either the pulsing relay (normally the A relay) or the holding relay (normally the B relay) is not working properly. The double dog spring with insufficient tension gives a similar response.

Since one mechanical trouble may mimick more than one electrical trouble, we are not describing this problem in depth. Secondly, we must limit our coverage, because you received this type of information in the resident course. Therefore, we will only provide an example trouble symptom and identify a mechanical defect which could cause it.

Assume that following a subscriber's going off-hook, all the idle linefinders in the shelf stepped, one at a time, to his bank appearance and remained operated. NOTE: This happens only with this subscriber's telephone.

Your quick recall should identify that the only equipment that relates directly with this telephone is the line relay. Looking at Foldout 1, find this L relay. Now, find the ground at contact 10 and trace from it. Following through contacts 9 and 10 and 3 and 4 of relay L and through contacts 4 and 5 of relay N3, you arrive at the winding of relay C3. You should remember here that relay C3 is the start relay for the group relays, and a group relay's function is to stop the vertical stepping of the linefinder when its vertical wiper engages the marked vertical bank contact of the level on which the calling line is located.

We have seen, however, that all of the linefinders stepped to his marked bank and remained operated. Which component through which you traced marked the bank which holds these linefinders operated? Yes, it is the grounded contacts 9 and 10 of the L relay. Thus, if these contacts do not open properly following the group relay's operation, they could make you think a group relay is at fault. Several conditions could prevent these contacts from opening. For example, the relay does not operate fully when there is too much resistance or too little current. Also, dirty or shorted contacts or contact spring maladjustment could be the fault. Again, when only one subscriber's telephone is affected, the most probable trouble is the L relay. Inspect and test it.

Exercises (405):

Complete the following troubleshooting problems, using foldout 1 and the text for objectives 402 through 404, as necessary. State the probable cause for each trouble and the appropriate corrective action.

1. A shelf of linefinders will not step. When the group relays are checked, it is found that, in both groups, relay C3 operates when test jacks 1 and 2 are started, the A3 relay is operated, and the B3 relay functions normally. The trouble is in one of the 20 linefinder switches in the shelf.

2. The linefinders steps to the calling party's bank appearance (upper bank) and releases. The next idle linefinder steps to the same bank appearance and does not release. No relay contacts in the linefinder are at fault. Give the most probable electrical and the most probable mechanical causes of trouble and how to correct each.

3. When the group relays for group A of a given linefinder shelf are in use, the linefinders release during rotary stepping and a trouble transfer occurs. This is an electrical problem due to a mechanical adjustment.

4. The A group relays have transferred all calls to the B group relays; but the subscribers for vertical levels six and up cannot initiate a call.

CHAPTER 2

Selector Equipment

EVERY IMPORTANT event in life must have a beginning and an end. Usually between these two positions there are actions that are not too obvious, but that are equally as important to a successful completion. This situation is equally true in a successful connection between two telephones. The lifted handset operates the line relay of the central office equipment, which resulted in a connection, through the linefinder, to the first selector. Many things must occur in this selector unit before that final connection is made which permits the conversation to proceed.

2-1. Selector Types and Shelves

You have learned in the resident course that a selector is a two-motion stepping switch used to partially complete the connection between a calling telephone, which has been seized by a linefinder, and a called telephone. It is generally called a seminumerical type switch, because it steps its wipers vertically in response to the dial pulses and then automatically rotates the wipers horizontally in search of an idle trunk.

406. Identify telephone switching equipment selectors and relate in some detail how they are installed. Use figure 2-1 as needed.

When the selector finds an idle trunk, it disconnects its own control relays from the calling line and connects that line to the trunk, so that the pulses of the next digit dialed will operate the next unit in the switch train. This unit may be either another selector or a connector. The trunk hunting begins right after the dial has stopped momentarily and before it is operated for the next digit. If the selector does not find an idle trunk on the level dialed, it rotates its wipers to the eleventh position of that level and returns an ATB (all trunks busy) tone to the calling telephone to indicate that all trunks on that level are in use.

Types of Selectors. Selectors are generally classified according to their position in the switch train—first selectors, second selectors, or incoming selectors. The use of various terms to describe selectors does not always mean that the selectors are different in any way. First selectors and second selectors in the same central office may be the same in all mechanical details. There are times, however, when you may need to include, in one group of selectors, mechanical or circuit functions not included in another group. For example, it may be necessary to equip the first selectors of a military dial central office with mechanical and circuit arrangements to restrict certain lines from calling off base. Second selectors in the same central office will not need the restricting feature and will thus differ somewhat from the first selectors just described.

For a selector to provide restricted service, it must be equipped with auxiliary contact springs. These are called *normal post springs*. They are mounted on the normal post and are operated by a cam (normal post cam), which moves vertically with the switch shaft. Teeth on the cam are adjusted to operate the normal post springs at a certain level or levels. Whenever a first selector is dialed to the restricted level, the selector wipers rotate horizontally to the eleventh rotary position, and the selector connects ATB tone to the calling line. The busy tone, in this instance, indicates a service restriction rather than that the trunk is busy.

The first selectors are those that come right after the linefinder in the switch train. They respond to the pulses of the first digit of the telephone number dialed and usually are arranged to supply dial tone to the calling telephone. The shelf on which the first selectors are mounted is equipped and wired to provide dial tone. The wipers of the first selectors and the linefinders are connected to shelf jacks. The jacks of each linefinder are wired directly to the jacks of a selector, forming a linefinder-selector unit. In telephone language, this arrangement of connecting the wipers of one switch to the wipers of another switch is called back-to-back wiring. The bank contacts of the first selectors are wired to the jacks of the second selectors or connectors. This arrangement is called front-to-back wiring.

through the relay contacts of the switches.

Central offices with 100-point connectors that serve more than 100 lines or with 200-point connectors that serve more than 200 lines normally use selectors that respond to the first digit dialed. Central offices that serve more than 1000 lines (4-digit numbers) or more than 2000 lines (5-digit numbers) normally use second selectors in addition to the first selector. The first selector is controlled by the first digit dialed; the second selector, by the second digit dialed. In large commercial installations, third selectors are also often used.

The regular first selector that we shall study in this chapter contains five relays. They are as follows:

A - Pulsing (controlled by the dial)
B - Holding (holds preceding equipment)
C - Transfer (from vertical stepping to rotary stepping)
E - Auto-rotary (steps wipers automatically)
F - Cut-through (cuts the calling line through to the next switch)

Selector Shelves. Selector switches and their associated equipment are installed in groups of 10. Figure 2-1 shows a selector shelf arrangement. Accordingly, there are two bays separated by a distributing terminal assembly (DTA).

Odd-numbered bay 101 has 10 shelves with shelves B, D, F, H, and J installed close to, and to the left of, the DTA. Shelves with the same identification in the even-numbered bay are also close to the DTA but are to its right. There are 20 DTA positions to serve the 200 selector switches. You should remember that this DTA provides terminals for the bank wiring and for cross-connecting to the suceeding switch trunks. This is the equipment where the system grading is provided. You will review grading later in Chapter 6 of this volume.

The switch groups are mounted in a steel framework. The portion of the frame in which each group of 10 switches is mounted is called a switch shelf. Each selector switch is equipped with a switch jack assembly, which fits into a shelf jack assembly when the switch is mounted in its normal operating position. This arrangement provides a handy means of removing and replacing the individual switches.

Exercises (406):

1. Name the first telephone equipment switch that succeeds the linefinder during the development of a telephone connection.

2. Identify the types of telephone equipment selectors.

3. To how many dialed digits does a selector respond?

Odd Numbered Bay 101		DTA	Even Numbered Bay 102	
Shelf A 1 thru 10	**Shelf B** 11 thru 20	POS 1 POS 2 POS 3 POS 4	**Shelf B** 20 ---- 11	**Shelf A** 10 ---- 1
Shelf C 21 thru 30	**Shelf D** 31 thru 40	POS 5 POS 6 POS 7 POS 8	**Shelf D** 40 ---- 31	**Shelf C** 30 ---- 21
Shelf E 41 thru 50	**Shelf F** 51 thru 60	POS 9 POS 10 POS 11 POS 12	**Shelf F** 60 ---- 51	**Shelf E** 50 ---- 41
Shelf G 61 thru 70	**Shelf H** 71 thru 80	POS 13 POS 14 POS 15 POS 16	**Shelf H** 80 ---- 71	**Shelf G** 70 ---- 61
Shelf I 81 thru 90	**Shelf J** 91 thru 100	POS 17 POS 18 POS 19 POS 20	**Shelf J** 100 ---- 91	**Shelf I** 90 ---- 81

Figure 2-1. Selector shelf arrangement on bay frame.

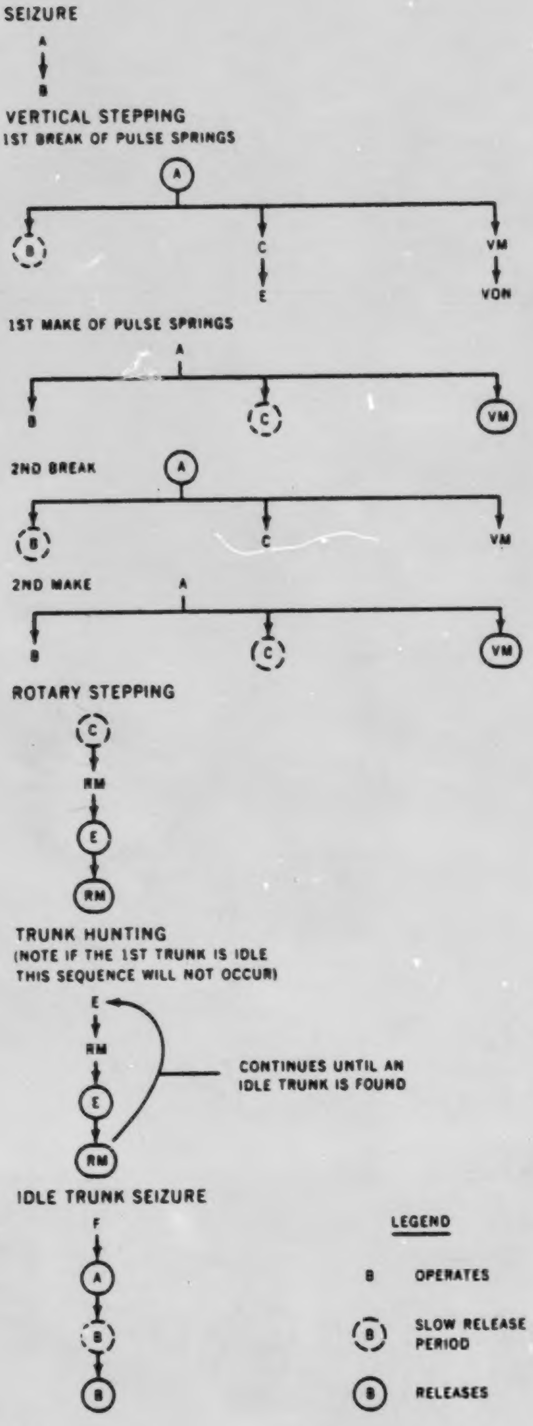

Figure 2-2. Selector normal operation sequence.

4. What Strowger selector component and equipment circuit permits connections which restrict service to certain lines?

5. What is connected to the selector banks?

6. A selector bay has provisions for how many selector switches?

7. Which selector bay and which shelf support switch number 175?

2-2. Selector Circuit Operation

A schematic diagram of a typical selector circuit is shown in foldout 2 in a separate inclosure. This diagram represents a basic first- or second-selector circuit, depending upon the position of the selector in the switch train. When used as a regular (local) first selector, the circuit connects dial tone current to the calling telephone through the grounded DIAL TONE and GND lead to show that the selector has been seized. When used as a second selector, however, the circuit transmits no dial tone current to the calling telephone, because the DIAL TONE and GND lead is connected to ground rather than through the secondary winding of a dial tone transformer. A three-wire trunk, consisting of a + line, a − line, and a C lead from a preceding switch in the switch train, is shown on the left-hand side of foldout 2. This trunk actually has a fourth conductor (not shown), the EC (extra control) lead. This lead is used to prevent restricted-service telephones from dialing certain levels on the first selector banks.

407. Using figure 2-2 and foldout 2 as required, name the selector relays operated at times of selector seizure.

Seizure. When the loop of the calling telephone is extended from the preceeding switch in the train (linefinder) to a first selector, the operating circuit of selector relay A is completed. It is through this circuit that dial tone, induced in the secondary winding of the dial tone transformer, is connected to the calling line by the first selector. The calling telephone user thus hears the regular steady hum of the dial tone right after lifting the handset from the cradle. This tone signal, provided only by the first selectors, tells the user that he can start dialing. Upon receiving the dial tone, the calling party proceeds to dial the digits of the desired telephone number.

The sequence of operation of the selector is given in figure 2-2 and the following paragraphs:

Relay A operates. Pulsing relay A is bridged across the + and − sides of the calling line loop when a selector is seized and pulses in response to the dial. Relay A operates because its operating circuit is completed over the loop through the dial of the calling telephone when the loop of the calling telephone is extended (switched through) from the linefinder to the selector. Operation of relay A completes the operating circuit of holding relay B.

Relay B operates. Relay B operates and partially completes (through contracts 2 and 3) a pulsing circuit for the future operation of relay C and the vertical magnet in series.

Right after seizure of the selector, the ground on the C lead holds the preceding switch (linefinder) operated during the time the selector is operating and until the holding circuit of the selector is extended to the next switch in the train (second selector or connector). The selector is now ready to respond to pulses from the dial of the calling telephone.

Exercises (407):

1. Which selector relay provides dial tone to the calling telephone?

2. Which operated selector relay connects ground to the C lead to hold the linefinder operated?

3. Which selector relay pulses during the dial operation?

408. Using foldout 2's selector schematic diagram, identify the selector equipment or actions that provide vertical stepping.

Vertical Stepping. When 2 dial tone is heard, the calling party dials the digits of the desired telephone number. Operation of the dial causes the dial pulse spring contacts, which are normally in the closed position, to break and make in rapid succession as the dial returns to normal, thus opening and closing the calling line loop. The number of such pulses, or interruptions in current, is equal to the number dialed. Since relay A is connected across the loop of the calling telephone, it restores and reoperates over the loop once for each dial pulse. Thus, if the digit 5 is dialed, relay A restores and reoperates five times.

First vertical step. (Operated: Relays A and B.) When the first digit of the desired telephone number is dialed, the relays in the selector circuit operate in the following sequence.

(1) Relay A restores and reoperates in response to the opening and closing of the dial pulse springs. For the duration of the first break of the dial contacts, relay A restores. When in this restored (unoperated) position, it closes the operating circuit of transfer relay C and the vertical magnet as seen in figure 2-2. Upon restoring, relay A also opens the operating circuit of relay B.

NOTE: Relay B does not restore when its operating circuit is opened by relay A, because its slow releasing action makes it stay operated during the time its operating circuit is open. This slow releasing action of relay B is due to the magnetic effect of the copper slug at the heelpiece end of its core.

(2) Relay C operates because relay A restores during the open period of the first pulse to close the operating circuit of relay C. Operation of relay C partially completes the operating circuit of relay E and the rotary magnet. Operation of relay C also shunts relay F to prevent the latter from operating during the interval between the operation of the VON (vertical off-normal) switch (SW-1) and operation of relay E. This is the first of three shunts on relay F. The operation of relay C thus provides ground on both sides of the winding of relay F, which is held in its normal unoperated position.

(3) Vertical magnet operates. Since the vertical magnet has its winding connected in series with the winding of relay C, its operating circuit is completed at the same time as the operating circuit of relay C. Therefore, the vertical magnet operates in response to the first dial pulse. Its operation raises the selector shaft one vertical step on the vertical ratchet, placing the shaft wipers in line with the first horizontal row of bank contacts.

(4) VON switch operates. As the switch shaft steps its wipers up to the first level of selector bank contacts in response to the first operation of the vertical magnet, the VON switch SW-1 operates mechanically and closes its normally open spring contacts. Thus, by the time the shaft has taken its first step upward, springs 2 and 4 have made contact with springs 1 and 3. Operation of the VON switch, shown in foldout 2, completes the first operating circuit of relay E. When the VON switch operates, it also completes part of the operating circuit of the release magnet. A circuit is thus prepared for the operation of the release magnet. (This permits the selector to be released at any time after its seizure, when relays A and B restore, the VON switch has operated, and relay F has not yet operated. If the handset is replaced on the cradle of the calling telephone just before the wipers of the selector has seized an idle trunk, the opening of the loop of the calling telephone will open the operating circuit of relay A. Relay A will then restore and opens the

operating circuit of relay B, thereby releasing relay B. Release of relays A and B completes the operating circuit of the release magnet to ground through contacts 4T and 5T of relay F, thus operating the release magnet. Operation of the release magnet then returns the switch shaft to its normal position.)

(5) Relay E operates. Relay E is called an auto-rotary relay, because by opening and closing contacts 3 and 4, it interrupts the operating circuit of the rotary magnet. Relay E operates first when its initial operating circuit is closed through spring contacts 3 and 4 of the VON switch SW-1 (see FO 2). When operated, relay E locks itself in the operated position by closing its own holding circuit. This holding circuit provides an alternate path to ground for the operating circuit of relay E. Thus, when relay C restores, after the last pulse of the first digit, and opens the operating circuit of relay E, relay E is held operated. Operation of relay E also partially completes the operating circuit of the rotary magnet. The locking of relay E in the operated position makes it possible to complete the operating circuit of the rotary magnets to ground at relay B later, when relay C restores. When relay E operates, it also closes a multiple shunt to relay F. A circuit, extending from ground at relay F through the winding of relay F to ground at relay B, is thus established to prevent completion of the operating circuit of relay F at this time. The second shunt on the winding of relay F occurs while the first shunt is still established. Thus, when the first shunting ground is removed from relay F by the release of relay C at the end of vertical stepping, the second shunt keeps F shunted. The second shunt of relay F prevents the relay from operating during the interval between the end of vertical stepping and the beginning of rotary stepping, just before the wipers take the first rotary step onto the bank contact of the first trunk on the dialed bank level.

(6) Relay A operates after the first pulse. At the end of the dial pulse, the dial contacts close, restoring the dial pulse spring contacts to their normal positions. This again closes the operating circuit of relay A to reoperate it over the loop. When relay A reoperates, it completes the operating circuit of relay B and opens the operating circuit of relay C and the vertical magnet. This action is also indicated in figure 2-2.

(7) Relay B remains operated. Relay B, which did not restore during the first pulse because of its slow releasing action, remains operated, since its operating circuit is complete again.

(8) Relay C remains operated. When relay A reoperates after the first dial pulse, relay C, which is slow releasing, holds itself operated for the fraction of a second, during which time its operating circuit is opened by relay A.

(9) Vertical magnet restores. When its operating circuit is opened by the restoration of relay A, the vertical magnet restores.

Additional vertical steps. (Operated: Relays A, B, C and E, and the VON switch SW-1.) For each dial pulse after the first, relay A restores during the open period of the dial pulse springs and reoperates during the closed period of the dial pulse springs. The moveable springs (sometimes called the lever spring or armature spring) of relay A reacts to the action of the dial pulse springs. Each time that relay A restores, its lever spring returns to its normal unoperated position, closes the operating circuit of the vertical magnet through the winding of relay C, and opens the operating circuit of relay B. When A reoperates, the operating circuits of relay C and the vertical magnet are opened, and the operating circuit of relay B is closed again. The vertical magnet operates and releases each time the armature spring of A relay breaks and makes, which, in turn, was activited by the dial pulse springs of the calling telephone. Each operation of the vertical magnet raises the shaft and the wipers one vertical step. The wipers are thus lifted step by step up to the bank level of the digit dialed. For example, if 4 is the first digit dialed, the vertical magnet operates four times, and the wipers are raised to the fourth level of bank contacts. The dialing of 0 as the first digit (0 being an abbreviation for 10 on a dial number plate) operates the vertical magnet 10 times, raising the shaft and wipers to the tenth or top row of bank contacts. The VON switch SW-1, however, is operated mechanically during the first vertical step of the shaft and remains in the operated position until the shaft returns to normal when the call is ended. Relays B and C do not restore during the pulsing period when their respective operating circuits are opened by the action of the armature spring of relay A. The slug on the heelpiece end of the coils of these relays enables them to remain operated for the short period of time they are disconnected from ground at relay F. Two exceptions are the VON switch SW-1 and relay C, which operate during the first vertical step. The sequence of operation for the selector on each step after the first is identical with that of the first vertical step. After reaching the dialed bank level, the shaft and wipers are ready for automatic rotation across the selected row of bank contacts in search of an idle trunk.

Exercises (408):

1. Identify the operated selector relays during the first break of the dial pulse springs.

2. What prevents relay F in the Strowger selector circuit from operating?

3. Is the Strowger switch "stepped" by mechanical or electrical actions, or both?

409. Using foldout 2's selector schematic diagram and figure 2-2 as necessary, give the selector components or actions that provide rotary stepping.

Rotary Stepping. After all of the pulses of the first digit which control vertical stepping have been received and the dial has returned to normal, the dial pulse springs come to rest in the normal closed position. Relay A, therefore, reoperates and remains operated. The selector is now ready for automatic rotary stepping.

First rotary step. (Operated: Relays A, B, C, and E, and the VON switch SW-1.) The sequence of rotary operation of the selector is as follows:

(1) Since relay A remains operated over the calling line loop, it holds relay B operated.

(2) Relay C restores. Look again at text figure 2-2. Relay A opens the operating circuit of relay C. Relay C remains operated during its slow release period and then restores. Once pulsing has ceased, relay C restores despite the delay caused by its heelpiece slug. With relay E still locked in the operated position, the release of relay C completes the operating circuit of the rotary magnet. Release of relay C opens the initial operating circuit of relay E by opening its contact 1 and 3. When relay C restores, it also removes the first shunt from the winding of relay F. Although the first shunt is disconnected from its winding, relay F is still prevented from operating by the second shunt on its winding.

(3) Rotary magnet operates. When its operating circuit is completed by the release of relay C, the rotary magnet operates. The operation of the rotary magnet rotates the shaft and its wipers one step from their position outside the dialed bank level to the first set of bank contacts. The rotary magnet, when operated, opens the holding circuit of relay E by opening the normally closed rotary interrupter springs (SW-2) through which the locking circuit of relay E was completed.

(4) RELAY E restores. When the rotary magnet operates and opens the holding circuit of relay E, relay E restores. The initial operating circuit of relay E was opened after the last dial pulse when relay C restored. Following release, relay E opens its contacts 3 and 4, opening the operating circuit of the rotary magnet. In the remainder of our discussion, the action of relay E depends upon whether the C wiper makes contact with a busy (grounded) or idle trunk.

(5) Rotary magnet restores. After restoring, the rotary magnet causes the rotary interrupter springs to return to their normally closed position.

Trunk hunting. (Operated: Relays A, B, and E, and the VON switch SW-1.) "Trunk hunting" is the automatic action of a rotary magnet in stepping the wipers over each set of contacts on the dialed bank level. Hunting continues until the wipers come in contact with an idle trunk or until they are stepped off the bank at the eleventh rotary step, when all the trunks are busy. This rotary stepping action is automatic and depends on each control bank contact engaged by the C wiper. Keep in mind that the control bank contacts of each group of selectors are connected in multiple in the same way that the line banks are multiplied; that is, control bank contact 11 on each of the other selector control banks. For example, when a selector seizes trunk 11, it makes the trunk busy by connecting ground to control bank contact 11. Since the control banks are connected in multiple, trunk 11 will be marked busy by all the selectors in the group. As the wipers are rotated across any row of control bank contacts, they test each trunk in that row, stepping by each grounded or busy trunk until they come to rest on an idle trunk or step off the bank. When the first trunk is busy, ground on the C wiper puts a third shunt on the winding of relay F before relay E, in restoring, removes the second shunt. The third shunt is removed from relay F only when the C wiper is stepped off the busy trunk. Relay F is thus prevented from operating as long as the C wiper finds ground on the control bank. Ground on the C wiper also enables the rotary magnet, which restores after the first rotary step, to complete the second operating circuit of relay E.

The sequence for the automatic trunk hunting is shown in figure 2-2 and outlined in the following paragraphs:

(1) Relay E reoperates. Relay E reoperates upon completion of its second operating circuit, which is completed from ground on the C wiper. When the relay operates, it recloses its own holding circuit. The operation of relay E also closes its contacts 3 and 4, which again completes the operating circuit of the rotary magnet. Contacts 1 and 2 of relay E again close the second shunt on relay F. This second shunt on relay F was completed when relay E first operated during vertical stepping. It is completed at this point in the rotary stepping sequence to prevent relay F from operating when its third shunt is removed during the time that the C wiper has broken contact with the grounded bank contact of a busy trunk and is advancing to the next contact.

(2) Rotary magnet reoperates. Since the operating circuit is again completed through contacts 3 and 4 of relay E, which controls its circuit, the rotary magnet reoperates and again steps the shaft and its wipers to the next set of bank contacts, that is, to the bank contacts of the second trunk on the dialed level. Reoperation of the rotary magnet, in turn, opens contacts 1 and 2 of SW-2, opening both the second operating and the locking circuits of relay E.

(3) Relay E restores. When its operating and locking circuits are opened by SW-2 during reoperation of the rotary magnet, relay E once again restores and opens the circuit over which the rotary magnets operate.

(4) Rotary magnet restores. When its operating circuit is interrupted at contacts 3 and 4 of relay E, the rotary magnet restores.

(5) Second trunk busy. If the second trunk is busy, the C wiper will find ground at the second control bank contact and again complete the second operating circuit of relay E, which connects the third shunt to prevent relay F from operating. Thus, relay E and the rotary magnet continue to interrupt each other's circuits to operate these relays, advancing the wipers step by step over the contacts of each busy trunk on the dialed level. This action between relay E and the rotary magnet and the stepping of the wipers over the bank contacts of each busy trunk both continue until the C wipers reach the control bank contact of an idle trunk, or until the wipers are stepped off the bank after finding all 10 trunks on the level busy. Relay F, moreover, remains shunted and cannot operate as long as the C wiper finds ground on the control bank contact of an idle trunk or until the wipers reach the eleventh rotary step.

Exercises (409):

1. Name the component which through magnetic attraction moves a shaft and wipers horizontally over a bank of contacts.

2. What connecting action (arrangement) provides that all associated selector contacts have the same electrical condition for the moving wipers?

3. Identify the two selector components which operate alternately to move the switch wipers horizontally over the bank contacts.

410. Using foldout 2's selector schematic diagram, name the selector devices or actions that seize an idle trunk.

Idle Trunk Seizure. (Operated: Relays A and B, and the VON switch SW-1.) When the + and − line wipers are stepped to the line bank contacts of the first idle trunk on the dialed level, the C wiper will be stepped to the idle control bank contact of the same trunk. The absence of ground on the control bank contact found by the C wiper prevents the completion of a second starting circuit for the reoperation of relay E, which restored when the rotary magnet last operated. This ungrounded condition of the C lead of an idle trunk prevents further rotary stepping. In addition, when relay E restores, it will remove the second shunt from relay F's winding. Since there is no ground on the C wiper then, the third shunt of relay F is open. When the C wiper seizes an idle trunk, the last of the shunts of relay F is removed, allowing relay F to operate. The cut-through operation takes place in the following sequence:

Relay F operates. Since the function of relay F is to switch the loop of the calling telephone from the first selector through to the next switch in the train, it is called the cut-through relay. During vertical and rotary stepping, relay F remains shunted: first, from ground at relay B back to the same ground at relay B (when relay C operated during the first vertical step); second, from ground at relay B to ground at contacts 4T and 5T of relay F (when the VON switch operated during the first vertical step); and third, from ground at relay B to ground at the C wiper each time the wiper found a busy trunk. Each of the three shunts overlapped, so that when one was removed, another remained on the winding of relay F to prevent completion of its operating circuit. Thus, when the first shunt of relay F was opened while C relay was releasing at the end of vertical stepping, the second shunt took its place. When the second shunt was opened each time relay E was restored, the third shunt stopped relay F from operating. With the release of relay E and the connecting to an idle trunk by the C wiper, the operating circuit for relay F is now completed. A circuit for relay E is also completed, since the two relays are connected in series. Because of the way they are made, relay F will operate, but relay E will not operate when they are connected in series. Relay F has a high resistance winding (1300-ohm) and is designed to operate on a small amount of current. Relay E has a low resistance winding (210-ohm) and requires a large amount of current to operate. When the relays are connected in series, the total resistance of the two windings will not allow enough current to flow to operate relay E, but enough current will flow to operate relay F. Relay F opened its grounded break contacts 4T and 5T and its three sets of break-before-make contacts, disconnecting the + and − leads of the incoming trunk from the two windings of relay A and connecting +, −; and C leads to the +, −, and C wipers. This opens the operating circuit of relay A and the grounded contacts of relay F. The + and − leads are extended to the leads of the outgoing trunk leading to the next switch in the switch train (second selector or connector). Relay F connects the C lead of the selector to the C lead of the outgoing trunk from the selector banks to the next switch in the train, so that the next switch may return a multiple ground to hold relay F and the entire switch train operated after relay B restores. When relay F operates, its 5T and 4T contacts open and disconnect ground from part of the incomplete operating circuit for the release magnet, thus preventing the release of the selector after relay B restores. The calling telephone loop is thus extended through the first selector to the next switch in the train, completing the operating circuit of relay A of the next switch.

Relay A of the first selector restores. After relay F operates and opens the operating circuit of relay A at contacts 1B, 2B, 4B, and 5B, relay A restores, opening the operating circuit of relay B.

Relay B restores. Although its operating circuit is opened at two points, first, by the opening of contacts 4T and 5T of relay F, and a fraction of a second later, by the opening of contacts 2 and 3 of relay A, relay B does not restore right away, because it is slow to release. Relay B remains operated and keeps ground on the C lead long enough to allow relay B of the next switch in the train to operate and place a multiple ground on the C lead. This multiple ground on the C lead prevents the switches which have already been seized from being released when relay B of the first selector restores.

Relay A of the next switch operates. After relay F operates, it switches the +, −, and C leads of the incoming trunk through to the matching +, −, and C leads of the idle trunk to the next switch in the train. Relay A of the next switch now operates over the loop of the calling telephone.

Relay B of the next switch operates. Relay B of the switch which follows the first selector operates upon completion of its operating circuit by relay A of that switch. When relay B of the next switch operates, it connects ground to the C lead. The ground is applied to the C lead before slow-releasing relay B of the first selector has had time to restore and to remove its own ground from the C lead. The two grounds provide a safety margin which prevents the accidental release of the switches during connection between the first selector and the next switch in the train. This method of having a safety ground and extending holding and guarding circuits from one switch to the next is the basic principle of step-by-step automatic switching.

Relay B of the first selector restores. After a delay because of its slow releasing action, relay B of the first selector restores and disconnects ground from the C lead by opening its contacts 4 and 5. At this time in the sequence, the C lead remains grounded through the contacts of relay B of the next switch. When relay B restores, it partially completes a circuit for operation of the release magnet through contacts 2 and 1 of the VON switch SW-1, through contacts 1 and 2 of relay B, and through contacts 1 and 2 of relay A to contact 4T of relay F. This circuit is completed to ground through contact 5T when relay F restores. The release of relay B further opens the incomplete operating circuit of the vertical magnet (by opening contacts 2 and 3), the incomplete circuit to the rotary magnet (by opening contacts 4 and 5), and the first operating circuit of relay F (by opening contacts 4 and 5).

Relay F remains operated. Before relay B restores and removes ground from the first operating circuit of relay F, ground is connected to the C lead by relay B of the next switch in the train. When relay F operates after the first idle trunk is seized, it extends its own holding circuit to relay B of the next switch in the train by switching the C lead through to the C wiper resting on the first ungrounded control bank contact of the dialed level. Relay F is now held operated by ground at relay B of the next switch when the ground of its first operating circuit is removed by relay B of the first selector.

NOTE: Relay F is now the only operated relay in the first selector.

The loop of the calling telephone is now connected to the next switch in the train, and the calling telephone obtains current from relay A of that switch. Relay F remains operated for the length of the call to prevent the switch from releasing. The next switch in the train is, therefore, free to operate and to extend the loop to a following connector if the next switch is a second selector, or to the called telephone if the next switch is a connector.

Exercises (410):

1. Identify the line bank contacts.

2. Name the wiper that touches the idle control bank contact to seize a trunk.

3. Name the selector relay that connects the loop of the calling telephone to the subsequent switch.

4. What circuit factor limits the current in the components?

5. Name the Strowger selector relay that remains operated for the duration of the telephone conversation.

411. Using foldout 2's selector schematic diagram and figure 2-3 as required, specify the components or the circuit actions that release the telephone equipment following completion of a call.

Circuit Release Following a Completed Call. (Operated Relay F and the VON switch.) When the handset is replaced, the loop of the calling telephone is operated at the cradle switch, thus opening the operating circuit of the connector relay A.

Relay A of the connector restores. When relay A of the connector (the last switch in the train) restores, it

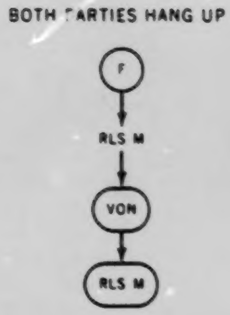

Figure 2-3. Selector normal release sequence.

opens the operating circuit of relay B of that same switch.

Relay B of the connector restores. Relay B of the connector, after a fraction of a second's delay, restores, and in so doing, removes ground from the C lead. Removal of ground from the C lead opens the operating circuit to relay F of the selector.

Relay F of the selector restores (see fig. 2-3). When ground is removed from the C lead, relay F restores and performs the following functions:

(1) Disconnects the +, –, and C leads of the incoming trunks from the +, –, and C leads of the outgoing trunk to the connector. Removal of ground from the C lead also releases the preceding linefinder.

(2) Closes the operating circuit of the release magnet.

Release magnet operates. When its operating circuit is completed to ground at relay F by the release of relay F, the release magnet operates. As the release magnet attracts its armature, the armature strikes the double detent, moving both the vertical and rotary detents away from the vertical and rotary ratchets. This permits the helical spring to rotate the shaft away from the bank level to its rotary position one step off the bank level, thus moving the wipers away from the bank contacts and the vertical ratchet of the shaft hub from the stationary detent. Since the shaft is no longer supported by the stationary detent, it drops to its normal position. As the shaft returns to its vertical position, it restores the VON switch SW-1. Release of relay F also completes the operating circuit of the release alarm, which is in series with the release magnet. This action provides an alarm if the selector fails to release.

VON switch restores. The VON switch, SW-1, which was operated mechanically as the shaft was raised to the first vertical step, remains in the operated position until the shaft returns to normal. As the shaft drops, its weight is again placed on the off-normal level, which normally holds the movable springs of the VON switch separated from its fixed springs. The operating circuits of the release magnet and the release alarm relay are opened at contacts 1 and 2 of the VON switch. These contacts are held open when the shaft is in its normal (unoperated) position.

Release magnet restores. After its operating circuit is opened at the VON switch, the release magnet restores. The selector is now released from all trunks and is ready to be seized for another call.

Exercises (411):

1. Name the first relay to operate in the Strowger connector circuit.

2. Identify the trunk lead and potential that holds selector relay F operated.

3. State the operational sequence for Strowger selector, connector, and linefinder when a call is developing.

4. Name the mechanical device(s) of the Strowger switch which holds the shaft in position while a conversation is in progress.

412. Using foldout 2's selector schematic diagram, isolate all components or circuit actions that indicate that all trunks are busy.

All Trunks Busy (ATB). (Operated: Relays A and B and the VON switch.) If the selector wipers, in hunting for an idle trunk on the dialed level, find all 10 trunks busy, they are stepped automatically off the bank to the eleventh rotary position. If there are fewer than 10 outgoing trunks from the selector bank level, the vacant contacts are grounded at the control bank to permit the wipers to step past them. As the switch shaft rotates its wipers off the tenth set of contacts on the selected bank level to the off-bank position, a cam clamped on the lower part of the shaft mechanically operates the cam springs (SW-3), which are mounted on the selector frame. During operation, contact 2 breaks with contact 1, and contact 3 makes with contact 5 before contact 5 breaks with contact 4. The ATB TONE and GND lead, which is connected to cam spring 3, is extended to the lower 200-ohm winding of relay A. This safety feature insures that ground for the operation of relay A will not be removed from the + line during the operation of the cam springs. In this way the cam springs, when operated, complete the ATB tone circuit to the calling telephone. The circuit is completed by disconnecting dial tone from selector relay A and replacing it with

ATB tone. When either dial tone or ATB tone current is transmitted, the alternating current for the audible signal is induced in the secondary winding of the dial or busy tone transformer and added to the direct current in the telephone circuit. The primary winding of the busy tone transformer is connected to an ATB tone interrupter. The ATB tone interrupted produces the regularly spaced tone pulses that are heard in the receiver of the calling telephone to signal the calling party to "hang up" and wait a few moments before lifting the handset and dialing again.

Dial tone is an audible signal showing that the selector is connected to the calling line and ready to respond to dial pulses; whereas ATB tone indicates that all trunks on the selected bank level are busy. ATB tone reaches the calling telephone over a path similar to that taken by dial tone. Its circuit extends from ground through the secondary winding of a busy tone transformer, through cam spring contacts 3 and 5, through the lower 200-ohm winding of relay A, through contacts 4B and 5B of relay F, to the + side of the line loop, through the calling telephone, to the − side of the loop, through contacts 2B and 1B of relay F, and through the upper 200-ohm winding of relay A to negative battery. The make-before-break springs of the cam spring assembly prevent the operating circuit of relay A from opening during the time the DIAL TONE GND lead is being disconnected and the ATB TONE and GND lead is being connected to the lower 200-ohm winding of relay A. That is, ground via the DIAL TONE and GND lead is not removed from the + side of the line loop until the ATB TONE and GND head has been connected to it.

Operation of the cam springs also further opens, at contacts 1 and 2, the incomplete operating circuit of relay F to prevent it from operating and releasing relay A when the C wiper does not encounter ground at the eleventh rotary step. With the wipers off the bank on the eleventh rotary step, there is no ground on the C wiper (as in the case of busy trunks) to shunt relay F. Since the C wiper is ungrounded at the eleventh rotary step, relay F will operate, unless its operating circuit is open or again shunted. Since there is no provision for shunting relay F at this point, cam springs 1 and 2 are opened as soon as the wipers step to the eleventh rotary position.

Exercises (412):

1. Give the maximum number of trunks the selector wipers move over before reaching the ATB position.

2. Name the switch that operates when all the trunks to the connector are found to be busy.

3. Compare the dial and ATB tones.

4. What difference should you notice if you test a C wiper for an idle trunk and a busy trunk?

413. Using foldout 2's selector schematic diagram and figure 2-4 as necessary, state the components or identify those circuit actions that release the telephone from All Trunks Busy condition.

Circuit Release When All Trunks Are Busy. (Operated: Relays A and B, the VON switch, and the cam springs.) If the handset of the calling telephone is placed on the cradle when ATB TONE is heard, the release of the selector circuit, seen in figure 2-4, is completed in the following sequence:

Relay A restores. When the handset is replaced on the cradle, the loop from the calling telephone to the selector is opened at the cradle switch, which opens the operating circuit of relay A. When relay A restores, it opens the operating circuit of relay B by disconnecting its winding from ground. Because of its slow releasing action, relay B remains operated for a moment after its circuit is opened, thus connecting the operating circuit of relay C and the vertical magnet to ground at relay F.

Relay C operates. Upon completion of its operating circuit by the release of relay A and the time delay in the release of relay B, relay C operates, but it performs no useful function at this time, except to open further the circuit for the rotary magnet at its opened contacts 2 and 3.

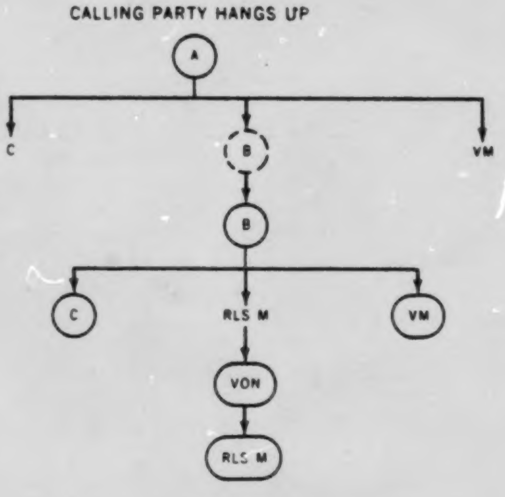

Figure 2-4. Selector release form ATB.

Vertical magnet operates. Completion of the vertical magnet operating circuit makes the switch shaft take one vertical step. This operation serves no useful function at this time. The shaft will fall back when the magnet restores.

Relay B restores. A fraction of a second after its operating circuit is opened by relay A, relay B restores and closes the operating circuit of the release magnet. This circuit is established from ground through contacts 5T and 4T of relay F, through contacts 2 and 1 of relay A, through contacts 2 and 1 of relay B, through contacts 1 and 2 of relay SW-1, through the 130-ohm winding of the release alarm relay to negative battery. Release of relay B opens the operating circuit of relay C and the vertical magnet and removes ground (at contacts 4 and 5) of the C lead to release all the switches in the train and to make this switch idle.

Vertical magnet restores. Opening of the vertical magnet circuit at contacts 2 and 3 of relay B releases the magnet's armature, thus dropping the vertical pawl back from the tooth of the vertical ratchet.

Relay C restores. When relay B restores, it opens the operating circuit of relay C at its 2 and 3 contacts, restoring relay C (after a moment of time delay).

Release magnet operates. Completion of the release magnet circuit of the selector returns the switch shaft and wipers to normal. As the shaft returns to its normal position, it restores the cam springs (SW-3) and the VON switch (SW-1).

Cam springs restore. The cam springs were operated by a cam on the switch shaft when the wipers were stepped to the eleventh rotary position. The cam springs are restored during the release cycle, when the shaft spring rotates the wipers off the eleventh rotary position, back to the normal position. Release of the cam springs removes the ATB TONE and GND lead from the lower 200-ohm winding of relay A and replaces it with DIAL TONE and GND lead in preparation for the next call. The operating circuit for relay A, however, remains open at the cradle switch of the calling telephone.

VON switch restores. The selector shaft, in returning to its normal position, mechanically restores the VON switch (SW-1). As SW-1 is restored, its 1 and 2 springs open the operating circuit of the release magnet.

Release magnet restores. Since its operating circuit is open at the VON switch, the release magnet restores. The selector is then released and may be seized for another call.

Exercises (413):

1. To operate relay C, what potential is connected to it by the released relay A?

2. Which selector switch magnet is the last to operate while the circuit is returning to normal?

3. List components of the release magnet operating circuit.

4. How are the wipers moved to the eleventh rotary position during selector release (mechanically or electrically)?

2-3. Troubleshooting the Selector

You have learned that searching for trouble is one of your tasks. In the previous chapter, we have reviewed a stepping switch trouble symptom which was caused by a circuit relay. Of course, the same stepping switch symptom may also be seen in the selector circuit. It could also be a relay defect. But, it could be caused by other defects. Moreover, additional trouble symptoms and troubles are to be found in the selector.

414. Given typical selector equipment trouble symptoms, and using foldout 2's schematic diagrams, determine the probable causes of trouble in each instance and state the necessary corrective actions.

The causes of most telephone circuit troubles are not easily identified, because several troubles may cause the same or a similar symptom. You should recall, too, that most good repairmen study the telephone circuit and use a basic knowledge of electricity and the system to isolate the probable trouble. In the following sample trouble, then, let's refer to the typical step-by-step selector schematic diagram while determining probables which could cause this symptom.

The trouble symptom is that the selector switch has stepped vertically and rotary, then released. What device(s) and what actions normally hold the switch operated during the call?

We said that relay F remains operated during the call to prevent the selector switch from releasing. When studying basic electricity, you learned two electrical conditions which can prevent a relay from operating or releasing are a shunt of it or an open in its operating circuit. The most common relay trouble is probably an open circuit.

Looking at relay F in the text schematic, we see that contacts 1 and 2 or the CAM switch, contacts 1 and 2 of the rotary magnet, contacts 3 and 4 of the VON switch, and the E relay winding are in the F relay holding circuit. Consequently, if any set of these listed contacts were dirty or open when they are supposed to be closed, relay F would not hold the switch in position. Also, the defect could be open contacts 2T

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and 3T of relay F, a maladjusted or dirty selector C wiper, an open or dirty bank terminal C, or open make contacts of the B relay in the succeeding switch.

From this study of the electrical circuit for the selector switch, we can again see that the probable trouble is a mechanical malfunction: relay and switch contact condition. Hence, you may correct the trouble by inspecting, testing, cleaning, and adjusting these units.

Exercises (414):

Use foldout 2 and the text information for determining the probable trouble that caused each of the following trouble symptoms. State an appropriate corrective action for each.

1. A selector was seized but released instantly following seizure.

2. A selector steps vertically but does not step rotary.

3. A selector steps vertically, rotary, and remains operated. It has not released.

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CHAPTER 3

Connector Equipment

THE CONNECTOR is the final switch for extending the calling telephone loop to the called telephone. The connector is similar in mechanical action and construction to the selector; but it has no vertical or rotary interrupter springs, since both its vertical and rotary movements are under the control of the dial of the calling telephone. The connector may be readily recognized by the large number of control relays mounted on its switch base. Thus, the connector, like the selector, is a two-motion stepping switch; but unlike the selector, which responds to the dial pulses of the first dialed digit, the connector operates in response to the dial pulses of the last two digits (TENS and UNITS) of the called telephone number. (The connector can be described as a fully numerical switch.)

As you might expect, there are several kinds of connectors. We shall discuss them next. Then we will review the connector circuit operation and troubleshooting.

3-1. Types of Connectors

You learned of four types of Strowger connectors in the resident course. The great majority of connectors are regular connectors which perform the functions listed next.

415. Label four types of Strowger connectors and give a function, similarity, or difference identifying each.

Regular Connector. You should recall that this connector does the following:

a. Upon seizure, it holds itself and all other switches in the switch train operated and busy to other calls until the connection is released.

b. It raises its wipers vertically and rotates them horizontally in response to dial pulses of the TENS and UNITS digits of the called telephone number.

c. It keeps the line wipers disconnected during rotary stepping in order not to interfere with the lines over whose bank contacts the wipers pass.

d. It tests the called line to determine whether it is engaged or idle, prevents the connections of the calling line with a busy line, and provides busy tone to notify the calling telephone that the called line is busy.

e. If the called line is idle, it extends the calling line through to the called line and makes both lines busy, so that the call will not be interrupted.

f. It fully operates the called line's combined line and cutoff relay.

g. It rings the called line and connects ringback tone to the calling line, showing that the called telephone is being rung.

h. It removes ringing current from the called line after the called telephone has answered.

i. It supplies battery current for talking purposes to both the calling and called telephones.

j. It releases when the last party hangs up. This lets all the other switches in the switch train release without interfering with other lines.

k. If it fails to release or if either the calling or called telephone user fails to replace the handset on the cradle, it provides a release alarm signal to notify central office personnel of the abnormal condition.

In order to do the many listed functions, it has the following eight relays:

A - Pulsing
B - Holding
C - Transfer (vertical to rotary stepping)
D - Battery reversal
E - Busy test
F - Secondary cut-through (ring cutoff)
G - Busy
H - Primary cut-through (ring start)

The circuit operation tracing and troubleshooting that we describe in this chapter are for the regular connector.

Trunk-Hunting Connector. Trunk-hunting connectors (sometimes called PBX connectors) are arranged for use where the traffic to a station, department, or office cannot be handled by a single line. For such a use, it is necessary to provide more than one line, although only one telephone number (that of the first line of the group provided) is listed in the directory. This first number is called the pilot number. Lines of such a group are all located on one connector level, and they are connected consecutively to the connector bank contacts. The connector wipers are moved by dial pulses to the bank contacts of the first trunk of the group. If that trunk is busy, the connector wipers automatically rotate to the bank contacts of the second trunk in the group. If the second trunk is busy, the connector wipers rotate to the bank contacts of the third trunk in the group. The automatic hunting process is continued until an idle trunk has been found. If all of the trunks in the called group are busy, the connector wipers stop on the bank contacts of the last trunk of the group, and the connector returns a busy tone to the calling loop.

Executive Right-of-Way Service Connector. Regular connectors may be arranged to provide a special type of service referred to as executive right-of-way service. When such a connector is dialed to a busy line, it returns a busy tone to the calling line in the usual way. If an urgent call originates at the executive telephone (one provided with the necessary equipment), a special switch on the executive telephone may be operated, causing the connector to extend the call to the called line, even though that line is busy. Conversation among the three telephones—the executive telephone and the two telephones originally connected—then may take place. Or, the calling party may request that both parties hang up. When this is done, the connector will ring the called party and the call will proceed as a normal call.

Test Connector. Test connectors are supplied as a part of each regular connector shelf and are mounted at the left end of the shelf. (Connectors are mounted in the supporting frame in groups in the same manner as the selectors, and each group is referred to as a shelf). The test connectors, used in conjunction with a test distributor, permit routine testing of the telephone lines from the test desk. Test connectors are not wired to supply ringing current, and any telephone to which the connector is dialed is signaled by ringing current supplied from the test desk.

Exercises (415):

1. Name the connector(s) which provides ringing, ringback, and busy tone to the line loop.

2. To which digit(s) of a dialed telephone number does the regular connector respond?

3. Identify one difference in connector bank connections for regular and trunk-hunting connectors.

4. Identify two types of connectors installed on shelf j in connector bay 102.

5. Compare the regular and test connector installation arrangements.

3-2. Connector Circuit Operation

Foldout 3 in the separate inclosure is a schematic diagram of a typical 100-point regular connector, which can be used to trace the operating sequence of the various circuits and relays. Let's begin by reviewing how a connector is seized.

416. Using foldout 2 and foldout 3's connector schematic diagrams and figure 3-1 as needed, determine the components or actions that seize the connector.

Seizure. A connector may be seized by a calling line using either a line switch or a linefinder if the system has less than 100 lines, or by a selector if the system has more than 100 lines. In the following circuit analysis, it will be assumed that the preceding switch in the switch train is a selector, since most central offices have more than 100 lines.

When the wipers of the preceding selector seize the bank contacts of an idle trunk leading to the connector, the loop of the calling telephone is switched through to the connector by the selector. At the same time, nothing is connected to the loop except relay F, shown in foldout 2, which is held operated during the cut-through period by a ground at relay B of the selector. Since selector relay B is a slow-releasing relay, it remains operated and holds selector relay F operated until its grounding function has been assumed by relay B of the connector. Relay F, held operated, thus prevents the release of the connection during the time between the seizure of an idle connector trunk by the selector wipers and the following operation of the connector.

Figure 3-1 shows the sequence of relay operations that are outlined in the following paragraphs. When selector relay F operates, it connects the +, −, and C leads of its three-wire incoming trunk to the selector wipers which are connected to the +, −, and C leads of the idle connector trunk seized. The loop of the calling telephone is thus connected from the selector banks to the connector, completing the operating circuit of connector relay A.

Relay A operates. Relay A operates over the loop of the calling telephone, extended by the selector, and closes contacts 2 and 3, thereby closing the circuit over which relay B operates. When relay A operates, it also

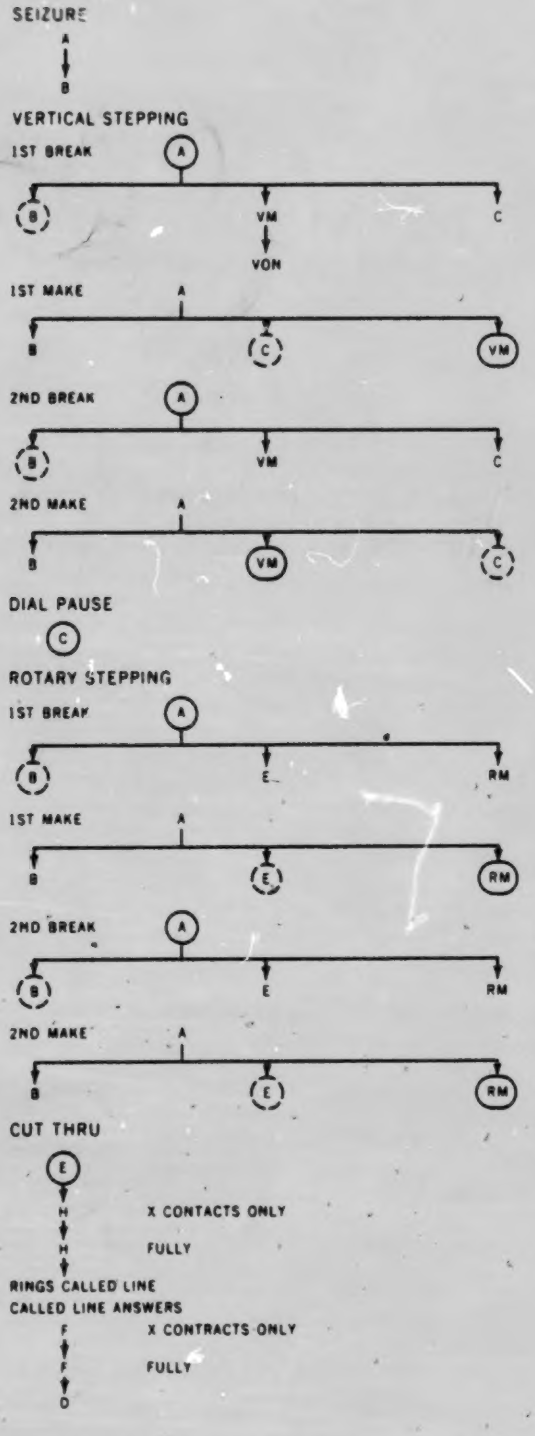

Figure 3-1. Normal sequence for 100-point connector operation.

opens the incomplete operating circuit of the release magnet by opening contacts 1 and 2.

Relay B operates. Relay B operates upon the closing of its operating circuit by relay A. Operated relay B performs the following functions:

(1) It connects ground to the C lead of the trunk (through contacts 6 and 7) to make the connector "busy" and to hold the L relay and the preceding switches in the train operated and guarded against seizure by other calls. This ground on the C lead multiples, for a moment, the ground on the selector C lead (from selector relay B), which has held relay F of the selector and the entire switch train operated. A moment after selector relay F operates, the release period of slow-releasing relay B of the selector ends. This causes it to restore. When selector relay B restores, it removes its ground from the C lead and from the operating circuit of selector relay F. Selector F, however, remains operated from the holding ground connected to the C lead by connector relay B. The C lead thus remains grounded, preventing any other selector, whose wipers may be trunk hunting on the dialed selector level, from seizing the busy connector. Since every connector can be seized and used by any one of a number of selectors, the trunk to the connector, when seized, is made busy (by ground from the C lead) at the control banks of all selectors to which it is available.

(2) It prepares the circuit over which relay C and the vertical magnet will operate. When operated, relay B closes contacts 2 and 3, through which the operating circuit of relay C and the vertical magnet will later be completed to ground at contacts 2 and 1 of relay A when relay A restores during the first dial pulse.

(3) It partially completes the operating circuits of relay E and the rotary magnet by closing contacts 2 and 3.

(4) It further opens the operating circuit of the release magnet by opening contacts 2 and 1.

(5) It closes contacts 4 and 5, thereby preparing a ground-return path for the operating circuits of relay H and relay F.

Exercises (416):

1. Identify the operated connector relay and the potential it provides which holds the preceding switches operated.

2. Name the connector A relay contacts and tell what action they provide when the relay is operated and released.

3. Detail briefly the procedure which seizes a telephone connector.

4. Identify the connecting method used to make a connector busy to all searching selectors.

417. Using foldout 3's connector schematic diagram, cite those components or actions which provide vertical stepping.

Vertical Stepping. When the next to last (TENS) digit of the called telephone number is dialed, the dial pulse springs of the calling telephone open and close once for each unit of the digit dialed. Relay A releases and reoperates a number of times equal to the number of dial pulses. Therefore, if the TENS digit dialed is 9, the dial pulse springs break and make contact nine times, and the operating circuit of relay A is opened and closed nine times.

First vertical step. (Operated: Relays A and B.) During the first break (open period or first pulse) in the loop, the operating circuit of relay A is opened, restoring relay A. Hence, the following sequence of operation results:

a. Relay A restores, performing the following functions:

(1) It opens the operating circuit of relay B by opening contacts 2 and 3. Relay B, however, is slow releasing, having a release time which exceeds the length of the break period on the loop during which its operating circuit is opened. Relay B, therefore, does not restore on the first dialed pulse but remains operated until its operating circuit is again completed at the end of the first pulse.

(2) Relay A closes the operating circuit for relay C and the vertical magnet by closing contacts 2 and 1.

b. Relay C operates and, because of its slow releasing feature, remains operated throughout the vertical pulsing period. The length of interruption in the loop caused by the first dial pulse is shorter than the release period of relay C. Relay C, in operating, opens the operating circuit of relay E at contacts 2 and 1. As relay C operates, it also partially completes its own holding circuit through contacts 2 and 3.

c. The vertical magnet's operation raises the switch shaft and its wipers one vertical step on the connector banks.

d. The VON switch operates during the first vertical step. In operating, the VON switch performs the following functions:

(1) It opens the initial operating circuit of relay C and the vertical magnet from ground at relay A by opening spring contacts 3 and 5.

(2) The VON switch completes a second operating circuit for the vertical magnet and a holding circuit for relay C by making contact 4 with contact 5, before contact 5 breaks with contact 3 to open the first operating circuit of relay C and the vertical magnet.

(3) The VON switch closes a portion of the operating circuit of the release magnet by closing its contacts 1 and 2. This permits the connector to release at any time after its seizure when relays A and B are restored, the VON switch is operated, and relay D is unoperated.

(4) The VON switch prepares a circuit for the operation of relay E by closing its make springs 4 and 5. This circuit will be completed at the end of the pulse series when relay C restores and closes contacts 1 and 2.

e. Relay A reoperates after the first pulse. When contacts of the dial pulse springs return to their normal closed position, the loop of the calling telephone is again closed to relay A, thus operating relay A again. When relay A reoperates, it performs the following operations:

(1) It again closes the operating circuit of relay B, which remained operated during the first interruption of its circuit.

(2) It opens the operating circuit of relay C and the vertical magnet by opening contacts 1 and 2.

(3) It also further opens the circuit to the release magnet by opening contacts 1 and 2.

f. Relay B which, because of its slow releasing action, was held operated during the first pulse, remains operated during the closed loop period following the first dial pulse.

g. During the reoperation of relay A after the first pulse, relay C, which is slow releasing, remains operated for the time during which its operating circuit was opened.

h. Vertical magnet restores. When its first operating circuit is opened by the release of relay A at the end of the first open period in the loop, the vertical magnet restores. Relay C, however, has partially completed its own holding circuit through contacts 2 and 3. This holding circuit of relay C, when completed on the second pulse, provides a second circuit for the operation of both relay C and the vertical magnet during each pulse after the first pulse of the series.

Second vertical step. (Operated: Relays A, B, and C, and the VON switch.) During each pulse or interruption of current in the calling telephone loop after the first dial pulse, the relays in the vertical pulsing circuit of the connector function in the following manner:

a. Relay A restores again when the second pulse is delivered by the dial, opening the loop for a moment and, with it, the operating circuit of relay A. Since relay B is held operated during pulsing, the release of relay A completes the holding circuit of relay C.

b. The vertical magnet operates once for each dial pulse over the circuit route established for it by the holding circuit of relay C. The first operating circuit of the vertical magnet, closed on the first pulse and then opened by the VON switch during the movement of the switch shaft up to the first step, is not used for further operations of the vertical magnet. Each time the vertical magnet operates in response to a pulse in the TENS digit series, it raises the switch shaft one vertical step on the connector bank. The vertical magnet thus follows the dial pulses of the TENS digit pulse train and lifts the shaft, step by step, up as many levels on the bank as there are pulses; for example, if the number 2359 is desired, 5 is the TENS digit. Therefore, five pulses would be transmitted to the vertical magnet by the dial pulse springs through the pulsing contacts of relay A. The vertical magnet would operate five times, stepping the shaft and wipers up to the fifth level. The wipers rest just one step outside the first set of contacts of the selected horizontal level of bank contacts.

Sequence after the last vertical step. (Operated: Relays A, B, and C, and the VON switch.) After the last pulse of the TENS digit, there is a pause before the last (UNITS) digit of the desired telephone number is dialed. During this interval the connector operates as follows:

a. Relay A remains operated, and upon completion of the TENS digit pulsing series, the dial contacts return to their normal closed position, thus completing the operating circuit of relay A. Relay A thus operates over the loop through the dial pulse springs of the calling telephone and remains operated until it is restored during rotary stepping. When relay A operates at the end of vertical stepping, it opens or closes the following circuits:

(1) It closes the operating circuit of relay B by closing contacts 2 and 3.

(2) It opens the holding circuit of relay C and the second operating circuit of the vertical magnet at contacts 1 and 2. While in the operated position, it holds open the circuit over which relay C and the vertical magnet operate.

(3) Relay A further opens the operating circuit of the release magnet by opening contacts 1 and 2.

b. Relay B remains operated. It remains operated throughout the period of vertical pulsing and while relay A reoperates after the last pulse. It holds open, at contacts 1 and 2, the circuit over which the release magnets operate.

c. After its holding circuit is opened at contacts 1 and 2 of relay A, relay C, with a delay of a fraction of a second because of its slow release action, restores. In restoring, it prepares the circuit over which relay E and the rotary magnet will operate when the UNITS digit is dialed. When releasing after the last pulse of the TENS digit, it transfers the pulsing circuit from the vertical magnet to the rotary magnet, which is connected in parallel with relay E.

Exercises (417):

1. How many times is the connector pulsing relay circuit interrupted when the number dialed is 2642?

2. Name the component which is operated when the Strowger connector switch steps vertically and identify its contacts and the circuits they complete.

3. How many times does the connector vertical magnet operate when the number dialed is 2135?

4. List the connector relays that operate to provide vertical stepping.

418. Using foldout 3's connector schematic diagram, determine all components or actions that provide rotary stepping.

Rotary Stepping. The pulse train of the UNITS digit operates the rotary magnet just as the pulse train of the TENS digit operates the vertical magnet. The UNITS digit, therefore, controls rotary stepping.

First rotary step. (Operated: Relays A and B, and the VON switch.) As the dial returns to normal after the UNITS digit is dialed, the dial pulse springs break and make as many times as the digit dialed, opening and closing the loop of the calling telephone. On the first pulse, the operating circuit of relay A is opened, and the sequence of operation thereafter is as follows:

a. Relay A restores during the first pulse. When at normal, it opens the operating circuit of relay B, which, however, does not restore because of its slow releasing action. In restoring it completes the operating circuit of relay E and the rotary magnet, which are connected in parallel. The pulses from contacts 1 and 2 of relay A now are delivered to the rotary stepping circuit instead of to the vertical stepping circuit. Since the 335-ohm winding of relay E is connected in parallel with the 57-ohm winding of the rotary magnet, the two relays have their operating circuits completed at the same time.

b. Relay E operates on the first pulse and performs the following functions:

(1) It closes a multiple holding circuit for itself and the rotary magnet by closing contacts 5 and 6. This holding circuit will hold relay E and the rotary magnet operated when their multiple circuit is opened at contacts 1 and 2 of relay G. This holding circuit, as well as the slow releasing action of relay E, holds relay E operated throughout the rotary pulsing period. The multiple holding circuit is established to prevent the

contacts of relay G, when relay G is operated, from interrupting the pulsing circuit to the rotary magnet. Contacts 6 and 5 of relay E, when closed, shunt contacts 1 and 2 of relay G to provide a pulsing circuit when relay G is operated.

(2) Relay E prepares a circuit for the operation of relay G by closing contacts 2 and 4. This operating circuit of relay G will be completed to ground at the C wiper during rotary stepping of the wipers across the dialed bank level when the control normal (CN lead) of the called telephone line is tested by the C wiper and found to be busy. Relay E thus connects relay G to the C wiper so that relay G may operate and provide busy tone current to the calling telephone if the called telephone is busy.

(3) Relay E further opens the operating circuit of the 125-ohm winding of two-step relay H by opening contacts 1 and 2. The circuit of relay H is completed later from negative battery on the CN lead of the called telephone line when the C wiper engages it on the control bank and finds it to be idle. Relay E allows either relay G or relay H to operate at any one time, but not both at the same time. The opening and closing of contacts 1 and 2 of relay E prevent relay H from operating and switching the calling telephone loop through to a busy telephone, but the closing of the 2 and 4 contacts of relay E operates relay G and returns busy tone to the calling telephone to indicate that the called line is busy.

c. The rotary magnet and relay E operate at the same time when relay A restores during the first pulse of the UNITS digit. When first operated, the rotary magnet moves the shaft one rotary step, rotating the wipers on the banks to the position of the first set of bank contacts.

d. When the loop is again closed at the end of the first pulse, the operating circuit of relay A is closed. When relay A reoperates, it functions as follows:

(1) It closes again the operating circuit of relay B to ground at contacts 2 and 3.

(2) It opens the multiple operating circuit of relay E and the rotary magnet at contacts 1 and 2.

(3) It also opens the multiple holding circuit of relay E and the rotary magnet.

e. During the period of its release from ground at relay A, when relay A restored, relay B remains operated. Now, with its operating circuit again established by the reoperation of relay A, relay B will continue to be operated. Thus, relay B remains operated throughout the pulsing cycle. It restores only when the loop is opened permanently—as, for example, when the handset of the calling telephone is replaced on the cradle.

f. At the end of the first pulse, when the dial pulse contacts close again and operate relay A, operated relay contacts open the operating and holding circuit of relay E. Slow-releasing relay E does not restore. Since its release period is longer than the period of disconnection from its operating and holding ground at relay A, relay E operated during the rotary stepping cycle.

g. The rotary magnet restores when its multiple operating and holding circuits are opened, because relay A reoperates at the end of the first pulse. The wipers thus come to rest for the moment on the first set of contacts in the dialed bank level.

Second rotary step. (Operated: Relays A, B, and E, and the VON switch.) On the second and on each remaining pulse of the UNITS digit dialed, relay A restores during the open period and reoperates during the closed period of each pulse, but relay B remains operated. Each time relay A restores, it closes the multiple circuit to relay E and the rotary magnet. Relay E remains operated during the pulsing period, since it is a slow-to-release relay. The rotary magnet, however, operates during each pulse and restores at the end of each pulse. On each operation of the rotary magnet, the shaft rotates its wipers one step on the dialed level of bank contacts. Thus, step by step, the wipers are moved across the dialed level until they reach the bank contact of the desired telephone line and they complete the call if the line is idle. This sequence of operation of a connector for each rotary step (after the first step) may be stated as follows:

a. Relay A restores during the open period of each pulse.

b. Relay A reoperates during the closed period of each pulse.

c. Relay B remains operated throughout the rotary pulsing cycle despite the opening of its operating circuit by relay A.

d. Relay E remains operated throughout the rotary pulsing cycle.

e. The rotary magnet operates once for each dialed pulse.

f. The rotary magnet restores at the end of each pulse.

g. The wipers take one rotary step each time the rotary magnet operates.

h. The C wiper tests each control bank contact on which it comes to rest.

i. At the end of the last rotary step pulse, the following sequence of operation occurs:

(1) Relay A comes to rest operated.

(2) Relay B remains operated.

(3) Relay E remains operated for a fraction of a second.

(4) The rotary magnet restores.

(5) The wipers come to rest on the bank contacts of the called line, which in turn are wired to the connector normals (+N, −N, and CN leads) of the called line (FO 3).

Exercises (418):

1. What dialed digit in the number 569-1382 controls rotary stepping of a Strowger connector switch?

2. Assuming that the subscriber telephone is idle, list the connector relays that operate before and during rotary switch stepping.

3. Identify the connector circuit connections that are made when the rotary switch has stepped to an idle telephone line.

419. Using foldout 3's connector schematic diagram and figures 3-2 and 3-3 as necessary, label those devices or actions that seize an idle trunk.

Called Line Idle. On the completion of rotary stepping, the wipers have been rotated across the dialed bank level to the bank contacts of the called line. From now on, the action of the connector will depend upon whether the called telephone line is busy or idle. If the called line is idle, it will be seized by the connector wipers. The control bank contact of the idle called line is connected through its control normal and through the cutoff winding of the combined line and cutoff relay (600-ohm winding of line relay L on the linefinder shelf) to negative battery. At this time, the wipers have just seized these connector normals of the called line. Both relays A and B are being held operated, and relay E has not yet restored. Since the wipers are touching the bank contacts of an idle line, the control bank contact of the called line is marked by negative battery instead of by ground. The following sequence of operation now occurs:

Relay E restores (Operated: Relays A, B, and the VON switch.) Shortly after the last pulse of the last digit dialed, relay E restores. The slow releasing action of relay E has enabled it to stay operated for a fraction of a second, during which it connected relay G through contacts 4 and 2 to the C wiper to enable relay G to make a busy test of the called line (FO 3). Since the called line is idle, relay G will not operate. The operation of relay G or its failure to operate is what makes up the busy test of a called line. When relay E restores, it performs the following functions:

a. It closes the circuit for the first step operation of relay H. This completed circuit through the 125-ohm winding of relay H operates its X contacts (1T and 2T, FO 3).

b. Its open contacts 2 and 4 further open the operating circuit for relay G from the C wiper.

c. Its contacts 5 and 6 open the multiple holding circuit of relay E and the rotary magnet.

Relay H operates its X contacts. (Operated: Relays A and B, and the VON switch.) Current going to the 125-ohm winding operates relay H to close its X contacts. The closing of the X contacts completes an additional operating and holding circuit through its 1300-ohm winding, which enables it to operate fully and lock operated.

Relay H operates fully. (Operated: Relays A and B, the X contacts of relay H, and the VON switch.) Energizing the 1300-ohm winding of relay H reinforces the magnetic attraction force of the 125-ohm winding and pulls the armature, which was attracted part way on the first step, all the way. Thus, the remaining contact springs of relay H are operated. Relay H remains operated for the remaining time that the call is in progress, being held in the operated position by the ground at the 4 and 5 contacts of relay B. Relay H will not restore until after both relay B and relay D restore upon completion of the call. Then the loops of both calling and called telephones are opened. When relay H operates fully, it performs the following circuit functions:

a. It opens contacts 3T. This cuts off the rotary magnet operating circuit from relay A as a safety measure against further rotary stepping of the wipers beyond the bank contacts of the called line which has been seized. Thus, should the dial of the calling telephone be operated at this time, the pulse would not reach the rotary magnet, since its operating and holding circuits have been cut off (that is, for the length of the call) from the pulsing contacts of relay A by the opening of contacts 3T and 4T of relay H.

b. It further opens, at contacts 1B and 2B, the operating circuit of relay G as a further safety measure against its operation (FO 3).

c. It connects ground to the C wiper and C lead by closing contacts 5B and 6B. A multiple ground is thus applied to the C lead, which is already grounded at the 4 and 5 contacts of relay B. The control bank contact on which the C wiper is resting is multiplied with the bank contact on the control banks of all other connectors of the group. Grounding of the C wiper and the multipled control bank contacts of the called line makes the called line busy.

d. It extends the loop of the calling telephone through to the called telephone (for ringing and talking) by closing its make contacts (5T and 6T), thereby connecting the normally open + and − wipers of the connector to the +N and −N normal wires of the called line. This connects the outgoing +N and −N from the connector to the ringing generator circuit so that ringing current may be applied through the connector to the called line.

e. It completes the ringing circuit over the − side of the called line to the called telephone by closing contacts 6T and 5T. When operated fully, ringing current from the ringing generator is applied to the called telephone. The ringing generator has one of its two terminals connected to negative battery, which provides direct current to the ringing circuit during periods of both ringing and silence. This direct current provides a means of cutting off the ringing whenever the called party answers. The ringing current circuit extends from negative battery and the ringing generator (referred to as ringing current superimposed on negative battery), over the RINGING GENERATOR and NEGATIVE BATTERY lead to the called telephone. Relay F remains in the unoperated position, where it permits the ringing current to pass through its contacts until the handset of the called telephone is lifted in response to the ringing. Whereupon, its operating circuit will be closed, and the relay will cut off the ringing current.

f. It has partially completed the first operating circuit of relay F. At this time the ringing circuit is extended only as far as the capacitor in the ringer circuit of the called telephone set. The circuit to relay F will be completed when the handset of the called telephone is lifted from the cradle, which also removes the ringing circuit capacitor from the circuit of relay F.

g. It also connects ringback tone to the calling telephone by closing contacts 3B and 4B. Ringback tone is a ringing signal returned to the calling telephone to indicate that the called line is being rung. The periods of ringing and silence for ringback tone is the same as that for ringing current. The capacitors in the ringback tone circuit block direct current but permit the alternating ringback tone current to flow.

Relay F operates its X contacts. (Operated: Relays A, B, and H, and the VON switch.) The removal of the handset from the called telephone completes a direct-current circuit across the + and − line wipers and through the 200-ohm winding of relay F. The closing of the X contacts of relay F completes a circuit from negative battery through its 1800-ohm winding to ground through contacts 4 and 5 of relay B. Thus, relay F operates fully.

Relay F operates fully. (Operated: Relays A, B, and H, the X contacts of relay F, and the VON switch.) When relay F operates fully, it performs the following circuit functions:

a. It locks in the operated position and will remain operated until relay B restores.

b. It disconnects ringing current from the − side and generator ground from the + side of the called telephone line by opening contacts 6 and 7 and contacts 4 and 3. Ringing is thus cut off from the called telephone when the handset of the called telephone is removed from its cradle.

c. It disconnects ringback tone from the calling telephone at the same time that ringing current is cut off from the called telephone.

d. It extends the + and − normals of the called line to the + and − leads of the calling line and to the lower and upper windings of relay D, to complete the talking circuit between the calling and called telephones. This happens when ringing and ringback tone are cut off. Relay D is now bridged across the called line and is connected through to the called telephone. The operating circuit of relay D is thus completed.

e. Relay F connects ground from contacts 2 and 1 of relay D to the SUPY NO. 1 lead by closing contacts 11 and 10. This circuit opens when relay D operates.

Relay D operates. (Operated: Relays A, B, H, and F, and the VON switch.) When the called telephone user answers, relay F operates and switches the + and − normal wires from the ringing current supply to the + and − conductors of the calling line loop and to the two windings of relay D, Relay D operates. Relay D is bridged across the called loop during the talking period and thus acts as a part of a transmission bridge in supplying current to the called telephone for talking purposes. When relay D operates, it performs the following functions:

a. It changes the direction of current in the winding of relay A. When this is done, the polarity of the + and − leads will be reversed from that shown in foldout 3. This reversal of the direction of transmission current to the calling telephone happens at the make-before-break contacts of relay D, as shown in figure 3-2. Before relay D operates, transmission battery is connected as shown in figure 3-2,A. When relay D operates, it connects ground to the − side of the calling loop by closing contacts 7 and 8 so that the circuit is traced from negative battery, as shown in figure 3-2,B. Further operation of relay D then disconnects negative battery from the − side of the loop by opening the 8 and 9 contacts of the same combination, as the original circuit shown in figure 3-2,A, is disconnected, as shown in the upper portion of figure 3-2,C. The make-before-break springs (7-8-9) thus permit reversal of the negative battery connections to the calling line loop without opening the loop in the interval of reversal. At its lower make-before-break springs (10-11-12), operated relay D removes ground from the + side of the calling loop by opening contacts 11 and 12 (fig. 3-2,C) after connecting negative battery to the + side of the loop

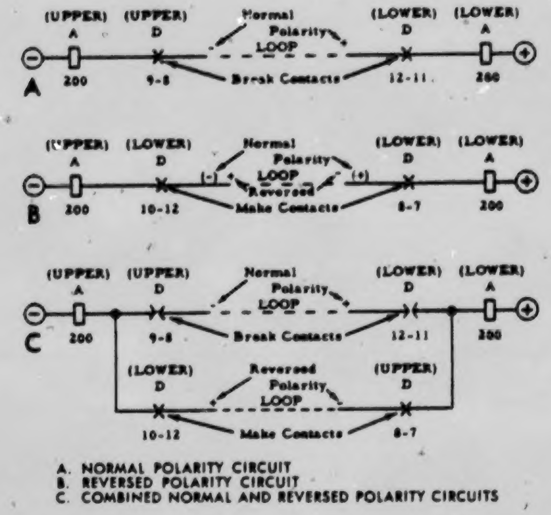

Figure 3-2. Reversing transmission current direction to the calling telephone.

by closing contacts 10 and 12, as in figure 3-2,B, and the lower portion of figure 3-2,C. Because the line loop is not disturbed during current reversal, loud clicks are not heard in the receiver of the calling telephone. Reversal of transmission current supply in the loop of the calling telephone is often required at the time the called party answers to operate metering equipment (such as message registers) at the calling line or to provide supervision, by an operator, of calls that originate at a manual switchboard. Thus, when a manual switchboard attendant dials the number of a dial-equipped telephone, this current reversal will operate the attendant's cord supervisory signal.

b. It closes a multiple holding circuit to lock relay F and relay H, operated by closing contacts 2 and 3. This locking ground to relay D is connected in parallel with ground at relay B. Thus, if the calling party hangs up first, relay B restores to remove ground from the operating circuits of relay F and relay H. These relays are prevented from restoring by the multiple locking ground from contacts 2 and 3 of relay D.

c. It further opens the operating circuit of the release magnet by opening contacts 4 and 5. This prevents the connector from being released during the talking period if the calling party accidentally hangs up. Relays A and B are held operated over the loop as long as the handset of the calling telephone is off the cradle switch. With relays A, B, and D operated, the release magnet circuit is interrupted at three points: namely, at contacts 4 and 5 of relay D and at contacts 1 and 2 of both relays A and B. Since relays A and B are controlled by the calling telephone, they will restore and close part of the release circuit to ground when the handset of the calling telephone is restored to the cradle switch. But relay D, being controlled by the called telephone, will still prevent completion of the circuit to the release magnet by remaining operated and holding the release circuit open. Thus, the seized connector cannot be released by the release magnet until both parties hang up.

d. It opens the supervisory circuit through the SUPY NO. 1 lead by removing ground from contact 1. This circuit closes when relay F operates fully and is opened an instant later when relay D operates.

e. It partially completes the SUPY NO. 2 circuit by closing contacts 5 and 6. This supervisory circuit, when completed by the release of relays A and B, lights a supervisory lamp on the power board to show that the calling telephone has been restored to its cradle.

Talking circuit. (Operated: Relays A, B, D, F, and H, and the VON switch.) The talking circuit over which direct current is supplied to the calling and called telephones is also referred to as the transmission circuit. Figure 3-3 is a schematic diagram of the talking circuit in the 100-point regular connector. The calling and called telephones are connected by a transmission bridge (or capacitance-impedance networks in a common battery system) which couples the two lines for the transmission of voice frequency currents but separates the two direct-current lines (talking battery). You can see that the talking circuit has four identical impedance coils separated by two capacitors. The two 200-ohm windings of relay A are the impedance coils which supply direct current for the calling telephone; the two 200-ohm windings of relay D are the coils which supply direct current for the called telephone. The lines between the two telephones are connected by means of two 2-microfarad capacitors (FO 3), which is the capacitance of the capacitance-impedance system. One capacitor is connected in series with the + side of the calling line loop and the other in series with the − side of the calling line loop. The direct-current circuits (relays A and D) for the calling and called telephones are thus separated by the two capacitors. The two impedance coils of relay D are bridged across the + and − conductors of the called line loop, and the two windings of relay A are bridged across the + and − conductors of the calling line loop. The impedance coils offer a low resistance (200-ohms) to direct current and a high impedance to voice current (alternating currents at voice frequencies). The low resistance of the two windings of relays A and D, which constitute the separate battery supply circuits of the calling and called lines, makes sure that each of the transmitters gets enough battery current. The high impedance of each pair of windings prevents alternating voice currents from passing through the battery. Thus, the battery-feed impedance coils prevent high transmission losses and keep battery noise from reaching the receivers.

The series capacitors allow voice currents but do not allow direct current to flow from the calling to the called telephone, or vice versa. When neither telephone user is speaking, the direct current in the two loops flows steadily, and no alternating current flows through the two capacitors of the transmission bridge. As the speaker's voice varies the resistance of the transmitter, the steady dc through the transmitter becomes varying dc. The flow of this varying dc, in

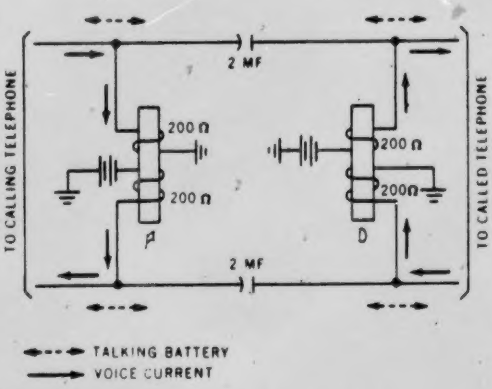

Figure 3-3. Talking circuit through the connector.

turn, produces ac at the two capacitors and through the other line loop to reproduce sound at the receiver. In figure 3-3 the solid line arrows indicate the path and direction of dc flow. The voice currents pass through the series capacitors between the two telephones but not through the windings of relays A and D, because the windings are inductive. It can thus be seen that the two telephone lines supplied with current by the transmission bridge are split at the feeding points (relays A and D) of direct current to each telephone, but they are coupled at the two capacitors for the transmission of voice currents.

Exercises (419):

1. Name the connector relays in the sequence that they operate to connect the calling telephone line to the called line.

2. Name the operated relay and contacts that connect ringing current to the called telephone.

3. Identify the relays and contacts that provide ringback tone to the calling telephone.

4. Identify the connector components in the talking battery circuit for the calling party.

5. Identify the connector components in the talking battery circuit for the called party.

6. What connector action provides an operator a supervisory signal?

7. What type current is provided by the connector for the telephone receiver?

420. Using foldout 3's schematic diagram, and figures 3-4 and 3-5 as required, list or name all devices or circuit actions that release the telephone equipment following completion of a call.

Release. When the conversation between the calling and called party is completed, both handsets are restored to their cradles. The following paragraphs will explain the sequence of relay operations and release covering the two types of situations that can occur during release—first, if the calling telephone user hangs up first; second, if the called party hangs up first.

Calling party hangs up first. (Operated: Relays A, B, D, F, and H, and the VON switch.) If the calling party hangs up first, the operating circuit of connector relay A is opened at the cradle switch of the calling telephone. The release sequence is shown in figure 3-4 and described as follows:

a. Relay A restores, opening the circuit to relay B.

b. Relay B remains operated long enough to complete the operating circuit of relay E.

c. When relay E operates, it locks in the operated position by closing its contacts 5 and 6 and opens the circuit over which the multiple ground is applied to the C lead (at contacts 1 and 2 of relay E). The C lead, however, remains grounded through contacts 5B and 6B of relay H. This makes the connector busy to incoming calls. Thus, the connector cannot be seized by another call until the called party hangs up. Operation of relay E also opens the first operating circuit of relay H at contacts 1 and 2. Relay H, however, remains operated, because the holding

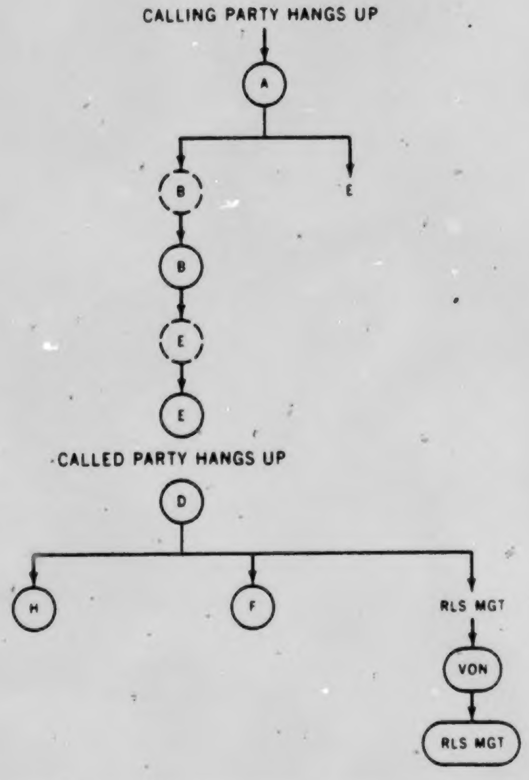

Figure 3-4. Connector release sequence when the calling party hangs up first.

circuit is closed through its X contacts and its 1300-ohm winding to locking ground at relay B.

d. Relay B restores and removes its holding ground from the incoming C lead, thus releasing all the other switches in the train. Release of relay B also opens the operating circuit of relay E.

In restoring, relay B performs the following functions:

(1) It opens the first multiple holding circuit of relays F and H. They do not restore at this time, since they are held operated by another multiple locking ground from contacts 2 and 3 of relay D.

(2) It further extends the operating circuit of the release magnet. The release magnet circuit is now extended from ground through contacts 2 and 1 of relay A, through contacts 2 and 1 of relay B, and up to contact 5 of relay D, at which point the circuit is interrupted. The release magnet circuit will thus be completed only when relay D restores after the called party hangs up. In other words, the connector will be released only when both calling and called parties disconnect.

(3) It closes the SUPY NO. 2 circuit from ground through contacts 2 and 1 of relay F, through contacts 2 and 1 of relay B, through contacts 5 and 6 of relay D, over the SUPY NO. 2 lead, and through a supervisory lamp to negative battery at the power board. This action lights the supervisory lamp to show that the calling telephone has been disconnected.

e. Relay E restores and reconnects the C lead to the C wiper.

Called party hangs up after the calling party. (Operated: Relays D, F, and H, and the VON switch.) When the calling party hangs up first, all of the switches in the train, except the connector, will be released by the release of relays A and B. The connector, however, will not be released as long as the called telephone handset remains off the cradle switch. The connector, in addition, is protected from being seized by another selector while the called party holds the connection because of the operation of relay E during the slow release period of relay B. (If the relay B were not slow releasing, relay E would not have operated, and the other switches in the train would have remained operated from the multiple ground of relay H on the C wiper.) The operation of relay E disconnected the grounded C wiper from the C lead for a fraction of a second. This is long enough to leave the C lead ungrounded, so that the other switches might restore.

Relay D, by the multiple locking ground at contacts 2 and 3, also holds relays F and H operated. Relays D, F, and H will not restore, therefore, until the called party hangs up. Thus, relays A, B, and D are the keys to the release of all the switches of a switch train. Here, then, is the condition of the connector circuit after the handset of the calling telephone has been restored on the cradle. One ground is removed from the C lead, but another ground is kept there by relay H. Relays D, F, and H remain operated, and the operating circuit of the release magnet is not yet complete. Further action does not occur until the called telephone user disconnects. When the called party hangs up, the operating circuit of relay D is opened at the cradle switch of the called telephone. The connector now releases in the following manner:

a. As relay D restores when the called party hangs up, the following sequence of functions occur, as may be noted by referring to foldout 3.

(1) Relay D removes its multiple holding ground from relays F and H by opening contacts 2 and 3. This removes the last remaining source of ground from the holding circuit of relays F and H.

(2) Relay D opens the SUPY NO. 2 circuit by opening contacts 5 and 6. This turns off the supervisory lamp on the power board to show that the called party has hung up.

(3) Relay D also restores the polarity of the calling line leads to normal to prepare for the next call.

(4) Finally, D closes the operating circuit of the release magnet by closing its contacts 4 and 5.

b. Relay H restores as its holding circuit is removed when relay D restores. When it restores, the following functions result:

(1) It disconnects the + and − sides of the calling line loop from the + and − normals of the called line. This disconnects the called line loop from relay D.

(2) It removes the ground, at contacts 5B and 6B, from the C wiper and, therefore, from the multiplied control normals of the called line. The removal of this ground releases relay L of the called line and makes this line idle and, therefore, free to be seized by another call or to make outgoing calls.

(3) It also further disconnects the ringing circuit from the − wiper, opens the incomplete ringback tone circuit from the − side of the calling line, and closes a part of the operating circuit of relay G. This prepares the busy test circuit for the next call.

c. When relay F restores, the following functions occur:

(1) It closes a part of the ringing and ringback tone circuit in readiness for the next call.

(2) It opens, at its contacts 10 and 11, the SUPY NO. 1 circuit.

(3) It further opens the called line loop to relay D.

d. Upon the closing of its operating circuit by relay D, the release magnet operates and allows the shaft and wipers to return to normal by the action of the helical shaft spring and gravity. When the release magnet operates, it also operates a release alarm relay which gives an alarm if the connector fails to return to normal.

e. The return of the switch shaft to its normal position restores the VON switch and thereby opens the operating circuit of the release magnet at springs 1 and 2.

f. Release magnet restores. Opening the operating circuit of the release magnet causes the release magnet to restore. The connector is now released and free to be seized by another call.

Called party hangs up first. (Operated: Relays A, B, D, F, and H, and the VON switch.) When the called party hangs up first, the called line loop is opened at the cradle switch of the called telephone, opening the operating circuit of relay D. The sequence of release when the called party hangs up first is shown in figure 3-5 and explained in the following paragraphs:

a. Relay D is restored after the called line loop is opened by the replacing of the called telephone handset on the cradle switch. Relay D, in restoring, performs the following functions:

(1) It reverses the ground and negative battery connections of the + and − sides of the calling line loop back to normal polarity. That is, it removes ground from and reconnects negative battery to the − line and removes negative battery from and connects ground to the + line of the calling line loop.

(2) It opens contacts 2 and 3 to remove a multiple ground from the holding circuits of relays H and F. Relays H and F, however, remain operated from a second ground at contacts 4 and 5 of relay B.

(3) Contacts 1 and 2 make to complete the SUPY NO. 1 circuit. This circuit extends from ground through contacts 2 and 1 of relay D, through contacts 10 and 11 of relay F, and over the SUPY NO. 1 lead to a supervisory lamp on the power board to show that the called party has hung up (FO 3).

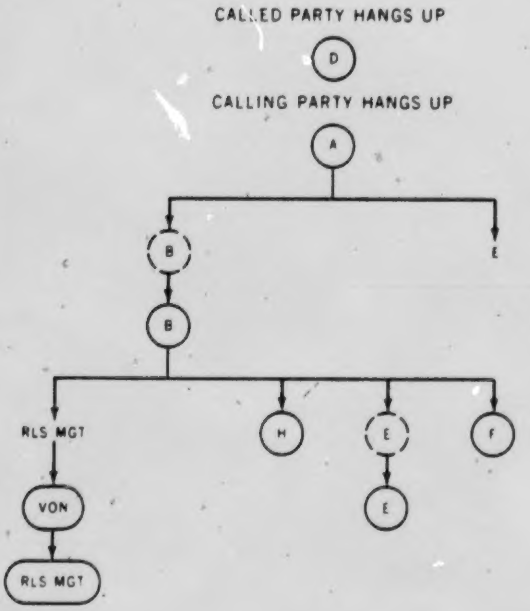

Figure 3-5. Connector release sequence when the called party hangs up first.

Calling party hangs up after the called party. (Operated: Relays A, B, F, and H, and the VON switch.) When the called telephone handset is the first to be replaced on the cradle, only relay D restores. The release magnet's operating circuit is still opened at the contacts of relays A and B. The connector, therefore, remains operated until the calling party hangs up. Thus, the connector releases only after the last telephone user (either the calling or the called party) hangs up. When the calling telephone user disconnects shortly after the called party has already disconnected, the resulting release sequence generally follows that outlined in (1) and (2) above, with the following exceptions: When relay B restores, it removes ground from the C lead, but the C lead remains grounded from contacts 6B and 5B of relay H. However, when relay B restores, it opens contacts 4 and 5 to remove the holding ground from relays H and F; then relays H and F restore. When relay H restores, it removes its multiple ground from the C lead, allowing the other switches in the switch train to release.

Exercises (420):

1. List the relays in a Strowger connector circuit that are operated for the duration of the conversation.

2. List the relays (in sequence) in a Strowger connector circuit that release when the calling party hangs up first.

3. List the relays in their release sequence for a Strowger connector circuit when the called party hangs up last.

4. List the Strowger connector relays in their release sequence when the called party hangs up first.

5. Name the connector relay contacts that complete the supervisory disconnect lamp circuit.

421. Using foldout 3's connector schematic diagram, and figure 3-6 as necessary, determine those components or circuit actions which indicate that the called line is busy.

Called Line Busy. During rotary stepping, relay E remains operated because of its slow releasing action. Relay E completes the operating circuit of relay G. The winding of relay G is thus connected to the C wiper during rotary stepping, making it ready to test the dialed line. As the C wiper is stepped to the dialed line, it may pass over contacts of idle lines. Even so, these lines will not be seized, because relay E is operated. The operating circuit of relay H remains open at contacts 1 and 2 of relay E until the wipers are stepped to the bank contacts of the dialed line, at which time relay E restores and transfers the C wiper from the winding of relay G to the 125-ohm winding of relay H. The wipers are thus stepped past the bank contacts of lines other than the called (which is determined by the last digit) line.

As the wipers step across the dialed level, they may pass over connector normals of lines that are busy (ground on the control bank). The operating circuit of relay G will be completed each time a busy line is passed over. Relay G will operate and restore for each busy (grounded) contact passed over by the wipers. Rotary stepping occurs so rapidly that relay G will not have time to operate long enough to return busy tone to the calling party. Busy tone will be returned to the calling line by relay G only when the wipers are stepped to the bank contacts of a dialed line, come to rest at those contacts, and find ground on the control normal of that line. After the last pulse of the UNITS digit of the dialed telephone number has been received by the rotary magnet, the wipers come to rest on the bank contacts of the dialed line. Relay A remains operated to open the operating and holding circuits of relay E and the rotary magnet.

The sequence of relay operation for returning busy tone to the called line if the called line is busy is shown in figure 3-6 and the following paragraphs:

Relay A remains operated over the calling line loop. (Operated: Relays A, B, and E, and the VON switch.) Relay A, by remaining operated, locks ground through its 2 and 3 contacts to hold relay B operated. Relay B, because of its slow releasing action, did not restore during the pulsing of the last digit series.

Relay E remains operated. (Operated: Relays A, B, and E, and the VON switch.) After its operating and holding circuits are opened by relay A, relay E holds itself operated, during which time it connects relay G to the C wiper through contacts 2 and 4. This permits relay G to make a busy test of the called line. When the called line is busy (C wiper contacts ground on the control normal of the called line), the operating circuit of relay G is completed.

Relay G operates. (Operated: Relays A, B, and E, and the VON switch.) When relay G operates it performs the following functions:

a. It partially completes its own holding circuit by locking to ground at relay B and by closing contacts 4 and 5.

b. It completes the circuit over which busy tone is returned to the calling party.

c. It further opens the operating circuit of relay E and the rotary magnet by opening contacts 1 and 2.

Relay E restores. (Operated: Relays A, B, and G, and the VON switch.) Because of its slow-releasing feature, there is a delay during which relay E completes the operating circuit of relay G to ground on the C wiper. After this delay, relay E restores and performs the following functions:

a. It completes a holding circuit for relay G. If the called line becomes idle while busy tone is being returned to the calling telephone, busy tone will continue to be heard, because relay G is locked in the operated position. Since relay G remains operated until the calling party hangs up and relay B hasn't restored to remove locking ground from the winding of relay G, relay H cannot operate and extend the calling line to the called line. The operating circuit through the 125-ohm winding of relay H thus remains opened at contacts 3 and 4 of relay G as long as relay G is held operated. A connector cannot, therefore, cut

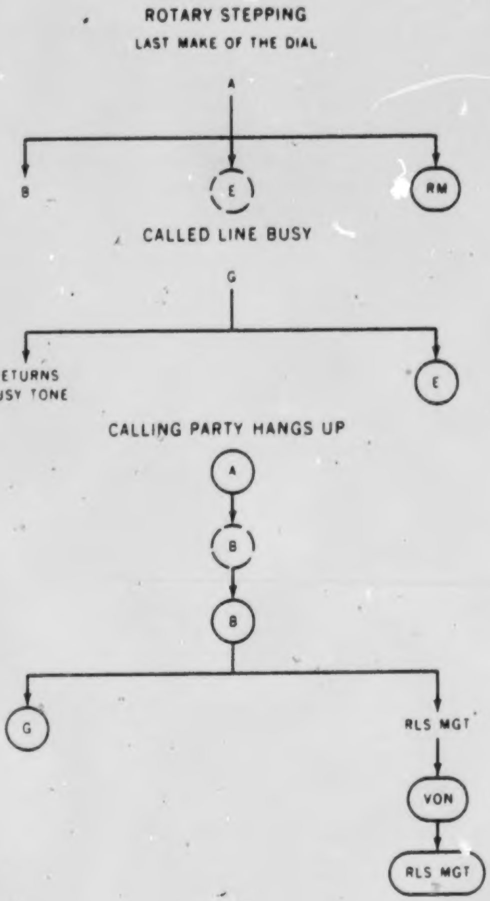

Figure 3-6. Connector operation sequence when the called line is busy.

in on a busy line which becomes idle during the return of the busy tone. Once busy tone is heard in the calling telephone, hanging up and redialing of the called telephone number are necessary to obtain connections with a line that was busy.

b. It further opens its own multiple holding circuit and that of the rotary magnet by opening contacts 5 and 6.

Release from a called line busy connection. (Operated: Relays A, B, and G, and the VON switch.) When the calling telephone user hangs up after receiving busy tone, the calling line loop is opened at the cradle switch, thereby opening the operating circuit of relay A. When relay A restores, it opens the operating circuit of relay B. When relay B restores, it opens the locking circuit of relay G and disconnects ground from the C lead. When the locking ground is disconnected at relay B, relay G restores and, in turn, disconnects busy tone from the calling telephone. At the same time, the release magnet operates, since its operating circuit was completed by the release of relays A and B. Operation of the release magnet returns the shaft and wipers to normal by the combined action of the helical shaft spring and gravity. As the shaft returns to vertical normal, the VON switch releases the release magnet. The connector is now free to be seized by another call.

Exercises (421):

1. When the calling number is 2212 and the called number 6930 is busy, what connector bank contacts operate the G relay?
2. Name the operated connector relays which provide busy tone to the calling telephone.
3. What procedure is required to release the Stowger equipment following return of busy tone?
4. Identify the Strowger connection circuit relays in the release sequence following receipt of busy tone and subscriber hangup.

3-3. Troubleshooting the Connector

Since there are many multipled connectors in a Strowger switching center, a trouble could exist and not be noted for a period of time. Yet, some equipment is common to all the connectors; therefore, when it is failing, all the connectors appear to be defective. Again, then, you should recognize that it is important that you analyse and isolate each trouble by studying the circuit(s) and recalling their operational functions and individual differences.

422. Given selected connector equipment trouble symptoms and using foldout 3's schematic diagram, determine the probable causes of trouble and state the corrective action needed for each situation.

Assume that you have a report of no ringback tone. One question that could be asked is "Did this occur at only one telephone each time the subscriber originates a call?" Or, "Did the report indicate that this occurred only once in 10 calls?" Or "Did the report indicate that this condition exists for all telephones?"

Analysis of the latter question should reveal that this symptom would indicate that the ringing source is defective, since ringback tone is provided by the same source that provides ringing current. But the report did not say that subscribers could not be signaled. Accordingly, the third question considered is not probable.

The first question is likewise not too probable because a subscriber telephone is served by many connectors and, therefore, the calls he makes are completed by various connectors. It is not likely that all connectors have the same defect.

Having looked at some of the trouble possibilities, then, we'll go back to the original report and assume that the defect is in the connector represented by foldout 3. What relay contacts in this circuit are probable causes for the trouble symptom noted? You should see that dirty or maladjusted contacts 3B and 4B of relay H and 8 and 9 of relay F could prevent ringback tone from being heard at the calling telephone. If you don't, trace the path through which ringback tone is fed to the calling phone.

Exercises (422):

Use foldout 3 and the text information to determine a probable trouble for each of the following reported trouble symptoms. Identify an appropriate corrective action.

1. A connector steps vertically but fails to step rotary.
2. Called party answered but the calling party could not hear him.

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CHAPTER 4

Alarm and Supervisory and Power and Ringing Equipment

THE NEED for power in a telephone system is obvious; something else that is required that is not so obvious is a way to monitor the condition of certain parts of the system.

In this chapter we look at the power equipment found in Strowger central offices and the alarm and supervisory circuitry that monitors equipment operation to warn you of equipment problems by means of visual and audible alarms.

4-1. Alarm and Supervisory Circuits Description

Automatic central offices are provided with equipment for giving alarms if a nonstandard condition arises. The alarms, both audible and visual, indicate the type of condition and the general location of the fault.

When an abnormal condition develops in the switching equipment, an audible alarm sounds and a signal lamp lights on the ceiling panel or on the end of a bay of switches. In the case of a ceiling panel, the lamp indicates by its color and designation the type of alarm and the bay or group of frames in which the trouble is located. Each shelf in the bay or group of frames has its own alarm and fuse panel. If the lamp is located on the end of a bay of switches, it does not necessarily indicate the type of alarm, but the shelf alarm signals do indicate the specific cause for the alarm. The audible alarm, in either case, indicates the general type of condition. A signal scheme is employed which guides the repairman to the particular bay and then to the shelf in which the trouble is located.

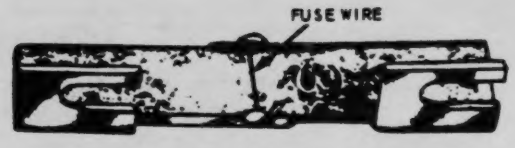
423. Using figures 4-1 to 4-3 as necessary, give the purpose of Strowger alarm and supervisory circuits and identify the relays in signal group 1, the length of one timing circuit cycle, whatever puts ground pulses on the TIME 1 and 2 of the supervisory circuit, the ground pulses' time duration, and the ampere ratings of indicator alarm fuses in a Strowger central office.

Alarm and Supervisory Equipment. The relay groups mounted on panels on the back of the powerboard in conjunction with the indicator-alarm fuses and the supervisory relays on the switching equipment shelves control all of the signal and alarm circuits.

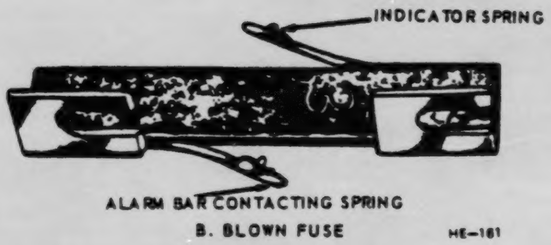
Indicator-alarm fuses. Special fuses used in telephone central office power circuits are designed to complete an external alarm circuit when the fuse operates because of an overload. These indicator-alarm fuses are usually supplied in 1-, 3-, and 5-ampere ratings. In circuits which require higher fuse ratings, standard fuses are used with an indicator-alarm fuse connected in parallel, so that it operates when the larger fuse blows. Figure 4-1 illustrates both a good and a blown fuse.

Signal group. A signal group for alarm and supervisory purposes consists of a bay or a row of bays of switching equipment. For each signal group, three relays are mounted on the powerboard, see foldout 4. These relays for eight signal groups are designated release pickup (RLS PU) C-1 to C-8, release alarm (RLS ALM) C-11 to C-18, and fuse C-21 to C-28.

Switching equipment (shelf) fuse and signal panels. Each equipment shelf normally mounts a fuse panel



A. 3 AMP INDICATOR FUSE



B. BLOWN FUSE

Figure 4-1. Indicator alarm fuse.

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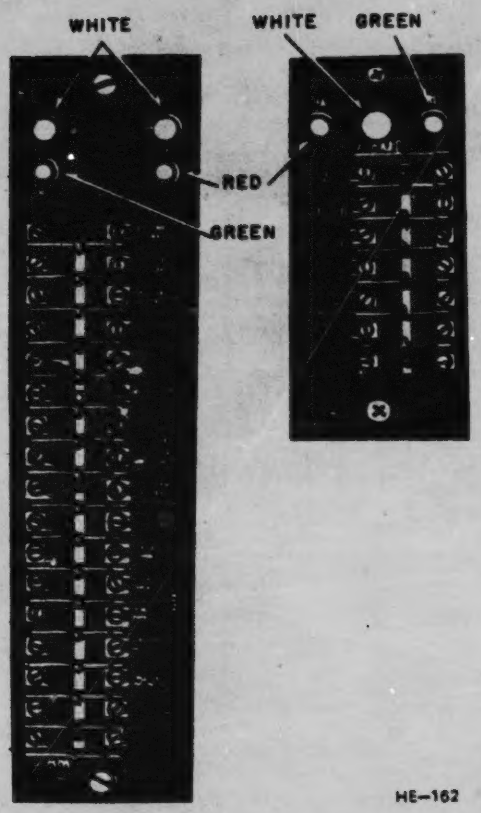


Figure 4-2. Typical shelf supervisory lamp panel.

and a signal panel, or a combination of the two, which serve the circuits and switches mounted on the shelf. The indicator-alarm fuses on the fuse panel and relays and lamps on the signal panel function with their associated relays on the powerboard to bring in an alarm and supervision if an abnormal condition occurs within that shelf. The lamps indicate by their color the type of abnormal condition that exists within the shelf. Refer to figures 4-2 and 4-3.

There are two types of central office alarms: major and minor. The major alarm is an immediate alarm requiring attention right now. The minor alarm starts as a normal condition, which after a certain time period becomes a trouble. The timing circuit for the minor alarms is controlled by periodic ground pulses sent from the interrupters of the ringing machines.

Timing circuit. The time control relays are constantly checking to see whether or not there is a need for an alarm. The time leads, designated TIME 1 and TIME 2, originate at the ringing machine interrupters. The cams on the ringing machine place a ground on TIME 1 and TIME 2 every 5 seconds. The timing relays are wired to give an alarm after the trouble has been in effect for a period of 9.5 to 19.5 seconds. The timing chart is given on foldout 4.

The pulses have a duration of one-fourth second. TIME 2 pulse comes $4^{1}/_{4}$ seconds after TIME 1 pulse goes off. TIME 1 pulse follows TIME 2 by one-fourth second, and the cycle repeats itself. This pulsing continues as long as the ringing machine is running.

Exercises (423):

1. What relays make up signal group number 1?

2. What is the length of one cycle of the timing circuit?

3. What equipment places ground pulses on the TIME 1 and TIME 2 of the supervisory circuit?

4. What is the time duration of the ground pulses?

5. What ampere ratings are the indicator alarm fuses used in a Strowger central office?

6. What purpose does the alarm and supervisory circuit serve in a Strowger central office?

4-2. Alarm and Supervisory Circuit's Operation

Now that we have looked at the components of the alarm and supervisory circuit, get foldout 4 out and let us see how this circuit works.

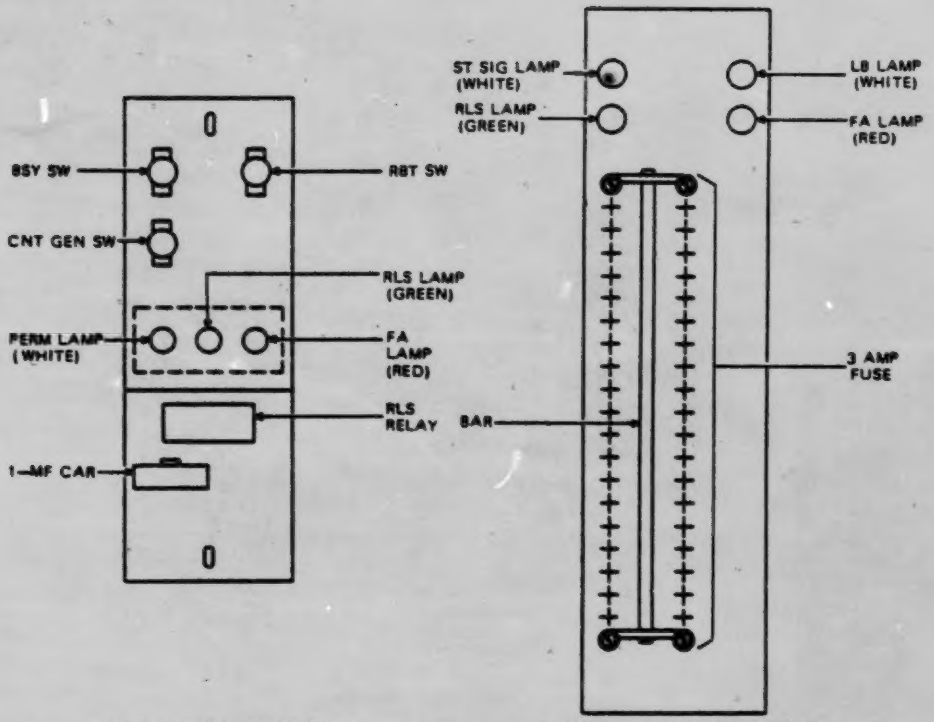
The first alarms that are discussed are delayed (minor) alarms and necessitate the use of the timing circuit, in the lower left-hand corner of the foldout.

424. Using foldout 4's schematic diagram, identify the actions that occur in the alarm and supervisory circuits during major and minor alarm conditions and state the purpose of representative relay contacts and of the capacitors connected in parallel with relay 39.

Minor Alarm, Release, Permanent, or Linefinder Start. These are delayed alarms. This type of alarm starts out as a normal circuit condition, that after a given period of time becomes abnormal.

TIME 1 goes on. Ground of the TIME 1 lead operates to B-6 relay. When the B-6 relay operates, the following occur:

a. Relay B-6 operates. Contacts 1 and 2 open the TIME 2 lead. Contacts 3 and 4 close the circuit to the B-8 relay. Contacts 5 and 7 make and hold the circuit



A. TYPICAL CONNECTOR SHELF SUPERVISORY LAMP PANEL

B. TYPICAL LINEFINDER FUSE AND SUPERVISORY LAMP PANEL

Figure 4-3. Typical shelf supervisory lamp panel.

to the B-6 relay. Contacts 6 and 7 open the original operating path for B-6.

b. Relay B-8 operates. Contacts 1T and 2T prepare a path for the operation of C-1 and C-7 relays. (Operate the C-1 or C-7 if there is a ground on the release, perm, and linefinder start.) Contacts 3T and 4T prepare a path to the C-2 and C-8 relays. Contacts 5T and 6T prepare a path to the C-3 relay. Contacts 1B and 2B prepare a path to the C-4 relay. Contacts 3B and 4B prepare a path to the C-5 relay. Contacts 5B and 6B prepare a path to the C-6 relay. At this time, the B-7 relay has its winding energized in the opposite direction, preventing it from operating.

TIME 1 goes off. Ground is removed from the TIME 1 lead and, consequently, from the lower winding of the B-7 relay. The B-7 will now operate from ground at the 5 and 7 contacts of the B-6 relay. Contacts 1 and 2 open the circuit to the lower winding of B-7 relay. Contacts 2 and 3 prepare the shunting path to the B-6 relay. Contacts 4 and 5 open the circuit to the B-8 relay and it releases. TIME 2 goes on and off, but serves no function at this time.

TIME 1 on. The ground on the TIME 1 lead is placed on the upper winding of the B-6, causing it to release. Contacts 1 and 2 prepare the path for the B-9 relay. Contacts 3 and 4 further open the operating path of the B-8 relay. Contacts 5 and 7 open the holding paths of B-7 and B-6 relays. Contacts 7 and 6 complete the ground from the TIME 1 lead to the lower winding of B-6 and the upper winding of B-7. The B-7 relay will stay operated until the ground is removed from the TIME 1 lead.

TIME 1 off. Ground removed from the TIME 1 lead allows the differential energizing path of the B-6 relay to be removed. The operating path of the B-7 relay is opened and it releases.

Relay B-7 releases. Contacts 1 and 2 prepare the path for the B-7 when TIME 1 again places a ground on this circuit. Contacts 2 and 3 open the circuit to the upper winding of the B-6 relay. Contacts 4 and 5 prepare the circuit to the B-8 relay when the B-6 operates again.

TIME 2 on. Ground on TIME 2 lead operates the B-9 relay.

Relay B-9 operates. The contacts of the B-9 relay partially complete the operating path for the RLS ALM relays.

TIME 2 off. Relay B-9 releases, and its contacts remove the negative potential that was prepared for the RLS ALM relays. This completes one complete cycle and takes approximately 9.5 seconds. Now, let's say that we have a ground coming from a release, permanent, or linefinder start lead. This ground is extended through the 1400-ohm and the 12.5-ohm resistance of the RLS PU relay, the 5 and 4 contacts of RLS PU relay, to the make contact of the B-8 relay. When TIME 1 goes on, B-6 will operate, and its contacts will operate the B-8 relay, which will operate the RLS PU relay which will lock up.

a. Relay RLS PU operates. Contacts 1 and 2 prepare the operating path to the RLS ALM relay. Contacts 4 and 5 open the operating circuit of the RLS PU relay; however, the make-before-break combination will prevent the RLS PU from releasing. Contacts 3 and 5 close the holding path to the RLS PU relay. At this point, there is no alarm because of the resistance of the RLS PU relay. When the RLS ALM relay operates, the visual and audible alarm will be activated. The RLS ALM relay will not operate until TIME 2 places a ground on the B-9 relay and it operates. (If the trouble is cleared, the RLS PU will release before an alarm is received.)

b. Relay B-9 operates. All the make contacts either prepare or make a path to the RLS ALM relays.

c. Relay RLS ALM operates. Contacts 1 and 2 complete the circuit to light the shelf lamp. Contacts 3 and 4 complete the circuit to the C-34 relay. Contacts 5 and 6 short the 1400-ohm winding of the RLS PU relay and places the 12.5 ohms in series with the shelf lamp, and it now lights. Contacts 7 and 9 complete the holding path to the RLS ALM relay. The RLS ALM and RLS PU relays will remain operated until the trouble is cleared.

d. Relay C-34 operates. Contacts 4 and 5 complete the circuit to the minor alarm buzzer. The audible alarm is now activated. The B-9 relay should have released by this time, but B-6, B-7, B-8, and B-9 continue to pulse and test for other troubles.

e. Relay RLS PU releases. When the trouble is cleared, the ground is removed from the lead coming from the shelf equipment and releases the RLS PU relay. Contacts 1 and 2 further open the RLS ALM relay circuit. Contacts 3 and 5 open the circuit to the RLS ALM relay, and it releases.

f. Relay RLS ALM releases. Contacts 1 and 2 open the circuit to the bay lamp. Contacts 3 and 4 open that circuit to the C-34 relay, allowing it to release. The other contacts of the RLS ALM relay have no function at this time.

g. Relay C-34 releases. Contacts 4 and 5 open the circuit to the buzzer. The circuit is restored to its normal condition.

Heat coil blows. When a heat coil is blown on the main frame, a circuit is completed from ground through the MDF pilot lead and operates the C-35 relay.

a. Relay C-35 operates. Contacts 1 and 2 place a ground on the C-34 relay, and the C-35 operates to bring a minor alarm buzzer. Contacts 3 and 4 place a ground on the MDF lamp and to a buzzer located on the main frame. The circuit will remain in this state until the heat coil is replaced.

b. Relay C-35 releases. When the heat coil is replaced, ground is removed from the MDF pilot lead and the C-35 released. Contacts 1 and 2 open the circuit to the C-34, causing it to release. Upon release, the C-34 turns off the audible alarm. Contacts 3 and 4 extinguish the MDF lamp on the power board and cuts off the buzzer on the main frame.

Major Alarm Fuse. A fuse panel with indicator alarm fuses is mounted on the relay rack, attendant's cabinet, and test desk. The alarm buzzer on these panels is connected through the alarm circuits (lamp and/or relays) to the alarm circuits on the powerboard. If an alarm fuse on this equipment blows, a major alarm is indicated by a red lamp on the equipment itself and, also, on the powerboard. The fuse relay on the powerboard, which operates through the spring on the indicator fuse, lights the red fuse alarm lamp on the powerboard and causes the major alarm bell to ring.

a. Relay C-21 operates. When a fuse blows on the shelf, it furnishes negative battery to operate one of the relays numbered C-21 to C-28. When one of these relays is operated, it closes the circuit to the C-33 relay through the 3 and 4 contacts. It also closes a circuit to the shelf lamp through its 1 and 2 contacts.

b. Relay C-33 operates. When the C-33 relay operates, 1 and 2 open the circuit of the C-38 relay.

c. Relay C-38 releases. Contacts 4 and 5 close the circuit to the major alarm bell and give the repairman an audible alarm. The alarm will sound until the MAJ. AL C.O. key is operated or the fuse is replaced.

d. Relay C-21 releases. When the fuse is removed, the C-21 releases. Contacts 1 and 2 open the signal lamp circuit. Contacts 3 and 4 open the circuit to the C-33 relay, allowing it to release.

e. Relay C-33 releases. Contacts 1 and 2 reclose the path and reoperate C-38.

f. Relay C-38 operates. Contacts 4 and 5 open the circuit to the major alarm bells.

The alarm and supervisory equipment on the switching equipment shelves, relay rack, test desk, and attendant's cabinet is connected to the associated alarm relays on the powerboard with supervisory terminal boards on the back of the powerboard. One end of the cable terminates at the supervisory terminal boards on the back of the powerboard, and the other end terminates at the signal terminal boards on the various equipment shelves. A supervisory terminal list is provided for the terminal boards at the back of the powerboard and shows the terminal numbers, color coding terminal designations, and what is connected to each terminal.

Relay rack, fuse alarm. The following circuit description is for a blown fuse in the relay rack equipment:

a. Relay C-37 operates. When a fuse on the relay blows, negative battery is extended on the RLY RACK FUSE CKT lead and operates the C-37 relay. Contacts 1 and 2 close a circuit to the C-33 relay, causing C-33 to operate and release the C-38 relay. Relay C-38 upon release brings in an audible alarm (bell). Contacts 3 and 4 light the RLY RACK lamp on the power panel. When the fuse is removed, the C-37 relay will release.

b. Relay C-37 releases. The C-37 upon release extinguishes the RLY RACK lamp and releases the C-33 relay. The C-33 relay upon release recloses the circuit to the C-38 relay, and it operates to silence the bell.

Test desk, fuse alarm. If a fuse blows on the test desk, negative battery is applied to the TEST DESK FUSE CKT. lead. This causes the C-36 relay to operate.

a. Relay C-36 operates. The circuits are the same as for the C-37 relay, except that the lamp labeled TEST DESK will light instead of the RLY RACK lamp.

b. Relay C-32 operates. If a fuse blows on the FUSE GRND, bus bar or the ringing machine, ground will be fed to the number 1 winding of the C-32 relay. Relay C-32 will operate and, in turn, will operate the C-33 relay. The C-33 relay will open the circuit to the C-38 relay, causing it to release and bring in an alarm. When the fuse is removed the C-32 relay will release, releasing the C-33, which in turn will reclose the circuit to the C-38 relay. Relay C-38 will operate and open the bell circuit. If a fuse blows on the MAIN BATT 1 or 2 bus bar, negative battery will be furnished through either MB FUSE 1 or MB FUSE 2 lamp to the lower winding of C-32 and operate the C-32 relay. The alarm will be received as we have described before.

Direct-generator, fuse alarm. If a DIR GEN fuse blows, the negative battery that is on the armature of the dynamotor will flow through the winding of the C-39 relay to ground, causing C-39 to operate. The ringing current applied on the same circuit has a path through the capacitors to ground. Contacts 1 and 2 close the circuit for an alarm, such as we have described previously.

High-Low Voltage Alarm. The relays B-12, B-13, and B-22 are associated with the high-low voltage alarm portion of the circuit. There is also a low-voltage relay. If the exchange voltage should drop below 46, this relay will release. Upon release, the C and A contacts close the circuit to the B-13 relay.

a. Relay B-13 operates. Contacts 1 and 2 open the circuit to the C-38 relay, allowing it to release. The C-38, upon release, gives an audible alarm. Contacts 2 and 3 close the circuit to the VOLT ALM lamp on the power panel. Contacts 4 and 5 prepare the circuit to the B-12 relay. When the B-6 relay contacts 1 and 2 have a ground extended from the TIME 2 lead, the B-12 will operate to test if the voltage is above 46V. This check will be accomplished every 9.5 seconds until something is done to relieve the trouble.

b. Relay B-12 operates. Contacts 1 and 2 open the circuit of the B-22 relay. Contacts 2 and 3 close the circuit to the low-voltage relay. However, if the voltage is below 46V, it will release when the B-12 releases. Contacts 4 and 5 prevent the B-13 relay's release when the low-voltage relay operates during testing. When ground is removed from the TIME 2 lead, the B-12 relay will release.

c. Relay B-12 releases. Contacts 1 and 2 reclose the path to the B-22 relay. Contacts 2 and 3 open the circuit to the low-voltage relay. Assuming the voltage is below 46V, it will release. Contacts 4 and 5 open the holding path of the B-13.

d. Low-voltage relay releases. The A and C contacts prevent the B-13 relay's release. This cycle will be repeated until the exchange voltage is above 46 volts. When the voltage rises above 46V and the low-voltage relay operates and stays operated, the holding ground of the B-13 relay will be removed and B-13 will release.

e. Relay B-13 releases. Contacts 1 and 2 close and reoperate the major alarm relay C-38, and the C-38 silences the bell. Contacts 2 and 3 open the VOLT ALM lamp lead. Contacts 4 and 5 open the testing circuit for B-12 relay. The high-voltage alarm works like the low-voltage alarm, except that when the voltage reaches 53V, the B-22 relay will operate.

f. Relay B-22 operates. Contacts 1 and 2 place a bypass around the resistor to hold the B-22 relay operated. Contacts 4 and 5 operate the B-13 relay, and the B-13 operates the same as we have described previously. The B-12 relay will continue to test until the trouble is corrected.

Exercises (424):

1. How many seconds will it take before relay B-6 operates when a ground is applied to the linefinder start lead in the alarm and supervisory circuit at the 1-second point in the 5-second cycle?

2. What is the purpose of relay C-11 contacts 5 and 6?

3. What causes relay B-6 to release after relay B-7 has operated?

4. What is the purpose of the capacitors connected in parallel with relay C-39?

5. What powers the major alarm bell?

6. If main battery 1 and 2 fuse alarm lamps burn out, will relay C-32 operate when a fuse blows? Why?

7. When does relay B-8 release?

8. Does the release alarm lamp go out when relay B-8 releases? Why?

4-3. Troubleshooting the Alarm and Supervisory Circuits

What happens when trouble occurs in the alarm and supervisory circuits? You do not have alarms or as many alarms as there really are. The lack of alarms may sound good, but it just makes your job harder. If you don't believe it, try finding a trouble without the help of lamps, buzzer, and bell.

Obviously, this circuit working properly is a help to you, but what if trouble crops up in the alarm and supervisory circuitry?

425. Given selected alarm and supervisory circuit trouble symptoms and foldout 4's schematic diagrams, determine the probable causes of trouble and state the corrective action needed for each situation.

Let us look at an example of an alarm and supervisory circuit trouble. You find a selector switch that has failed to release, but no alarm sounded. You check other selectors in other shelves of the same bay and find that no alarm is forthcoming. You then check other shelves in different equipment bays and alarms come in. This tells you that the timing relays and other signal group relays are working properly.

Let us assume the bay we are concerned with is hand fed by signal group 2. Looking at foldout 4, you can see the relays 2 and 12 are the relays we must check.

Well, where do you start? Between your ears. There was no alarm, visual or audible. We see from looking at the schematic that the audible alarm is connected to a different set of contacts than the visual alarm. Chances are, then, that relay C-12 isn't operating. Check it by having someone raise the shaft of a switch in that bay, and see if the relay (C-12) operates. If it does, then contacts 1 and 2, 3 and 4, and 5 and 6 are dirty or open. Let us assume that relay C-12 does not operate. What is the path for the operation of C-12? Through the contacts of relay C-2 to battery on the contacts of relay B-9. Does the C-2 relay operate, even for an instant, and then release? If it operates and then releases after an instant, the hold path through its 3 and 5 contacts is open. If it does not operate at all, then its 4 and 5 contacts are open, and/or 3T and 4T of relay B-8 are dirty or not making.

You can look at the relay and see it is operating. Assume that it is not operating. A simple continuity test then narrows it down; in this case, to dirty contacts 3T and 4T of relay B-8.

Exercises (425):

Identify the cause and state the corrective action for each of the following troubles, using foldout 4 as necessary.

1. When heat coils blow on the MDF, no audible alarm is heard.

2. No delay-type alarms are coming in when trouble exists. Relays B-6, B-7, and B-9 are operating, and no signal group relays are operating.

4-4. Power and Ringing Equipment Description

There are three major pieces of equipment used in the production and distribution of central office power. They are the battery charger, battery, and powerboard.

The powerboard of a typical dial central office consists of two vertical sections. The left section is designated No. 1; and the right section, No. 2. The powerboard provides space to fuse and distribute all negative and positive potentials, and panels for tones and supervisory equipment.

The rectifiers (Flotrols) are used to supply all of the power for the central office. The rectifiers are controlled by the toggle switches on the units. The Flotrol is manufactured by the Lorain Products Corporation, Lorain, Ohio. Sometimes other chargers are used in the field.

The dynamotor (ringing machine) is an ac generator driven by a dc motor which operates on 46-52 volts dc exchange battery.

The Holtzer-Cabot tone interrupter unit is driven by 46-52 volts central office battery.

426. State the purpose of the power and ringing equipment, consulting figures 4-4 and 4-5 as applicable.

Battery Requirements. Lead-acid battery cells are used in a typical central office main battery. The battery is used as a standby source of power. The load is taken off directly from the charger (rectifier) with

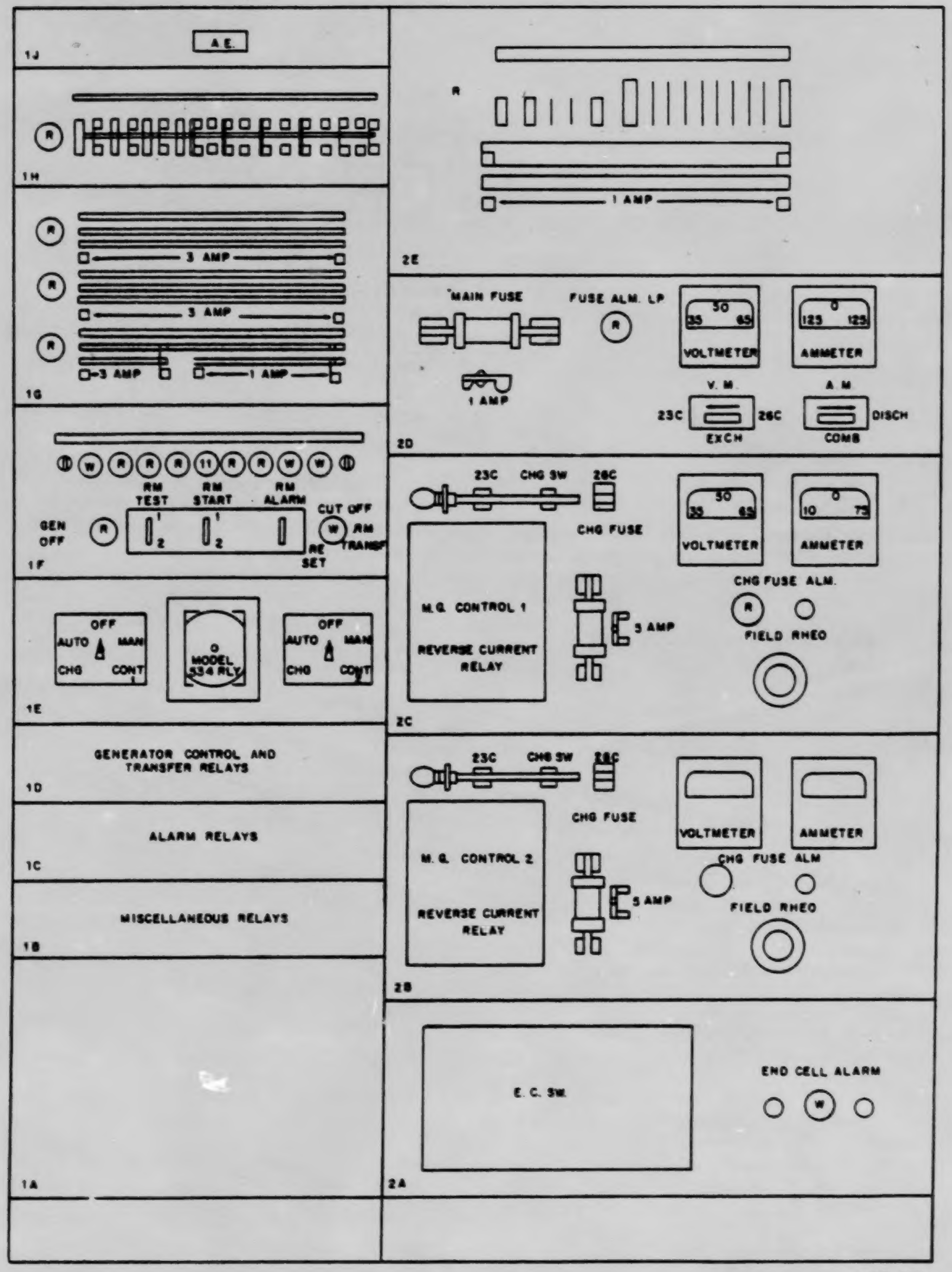


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Figure 4-4. Typical power panel.

the battery bridged across the load. Thus, the battery is kept charged constantly and is used only when the ac source is interrupted or when a sudden surge in the load demands more current than the charger can supply.

Type of cell. Cells are usually of the supported-element type in which the assembly of plates, separators, and retainers rest upon supporting ribs in the bottom of a molded steel-glass jar. The main battery consists of 23 cells, with one, two, or three additional cells called end cells for voltage boosting.

Battery capacity. The capacity of the central office battery is based on the normal operating load of each individual installation and may vary from 576 to 1,056 ampere-hours at an 8-hour discharge rate, according to the size of the cells. A battery with a 576 ampere-hour capacity would last for 8 hours at a discharge rate of 72 amperes per hour.

Powerboard. The powerboard of a typical dial central office, shown in figure 4-4, consists of two vertical sections. The equipment is mounted on a number of panels designated on the left section as 1A, 1B, etc., and on the right section as 2A, 2B, etc.

Contents of powerboard panels. These panels contain the following:

1B: Tone and miscellaneous relays. The function of these relays is covered later in this section.

1C: Alarm relays. This panel mounts the alarm and signal group relays.

1D: Generator control and transfer relays. These relays control ringing current from the ringing machines.

1E, 2B, and 2C. These panels mount controls for the dc motor generators.

1F. Ringing machine controls and supervisory lamps are mounted here.

1G. Fuses and alarm lamps for ringing, tone, and supervisory signal distribution circuits are located here.

1H. This fuse panel distributes power to the switchboard, relay rack, ringing machines, and test desk.

2A. End-cell control switch and its control circuits are not being used now.

2D. This is the discharge panel mounting the main fuse and indicator alarm fuse, voltmeter with a three-position switch (23 CELL, EXCHANGE, 26 CELL), and an ammeter with a two-position switch (COMBINATION, DISCHARGE).

2E. This is the power distribution fuse panel for the equipment shelves.

Meters. The discharge panel contains a voltmeter with a scale of 35 to 65 volts, and a zero-centered ammeter with a scale based on estimated peak busy hour current drain.

Voltmeter. The green rectangle on the voltmeter, the center of which is 49.5 volts, designates the normal floating charge. With the switching key in the EXCH position, the meter indicates the voltage across the 23 cells of the storage battery. This reading may be the actual voltage across the 23 cells of the battery on discharge or the voltage of the charging machine floating across the 23 cells and the exchange load.

The *charging unit must be disconnected from the powerboard bus bar* in order to read the voltage of the battery.

Ammeter. The ammeter can show either of two distinct current readings: combination (COMB) or discharge (DISCHG). The ammeter has an external shunt in the positive charge lead and in discharge lead. A switching key normally associates the meter with the COMB current. The key, when operated, connects the meter with the DISCHG current.

The combination reading indicates the difference between the charge and discharge current. Under normal operation, the meter should indicate zero (there is no current leaving the battery and none going to it). The charger floating across the battery and load generates current equal to the current being consumed. The discharge reading indicates the amount of current being consumed by the load (current used by the exchange).

Battery Charger. The three-phase automatic constant voltage battery charger, shown in figure 4-5, is a completely self-contained unit. With the exception of the starting, it does not contain any moving parts. All components are in one cabinet.

Specifically, the three-phase Flotrol operates on 208 to 230 volts, 60-cycle supply and delivers dc voltage regulated within the limits of ±1 percent to float charge the battery. The conversion of ac into dc is accomplished by means of long life selenium rectifiers. Regulation of the dc output voltage is controlled entirely by saturable magnetic reactors (iron cores with windings).

Each unit is equipped with a Weston voltmeter and ammeter. A simple switch changes the normal output voltage from 2.15 volts per cell to an equalizing voltage of 2.33 volts per cell. This is adjustable to 2.27 per cell where required.

Ringing Equipment. The output of the ac generator (direct generator) is 19 Hertz, 80 volts, used for ringing current. The Holtzer-Cabot single-frequency dynamotor, type HD, is lubricated at the factory and, after installation, needs oiling once a year. When reoiling, use SAE 30 machine oil, adding to each bearing until oil starts to drip from the overflow.

Oily commutators or collector rings should be cleaned with a hard, nonlinting cloth moistened with petroleum spirits, followed by a dry cloth. After cleaning, the commutator should be polished. A convenient and effective polisher may be made by using a hardwood stick of the following approximate dimensions: Length-15", width-1", thickness-3/16". One end should be covered with six or eight layers of hard woven canvas or duck cloth secured with rivets. The polisher should be applied "end on" to the

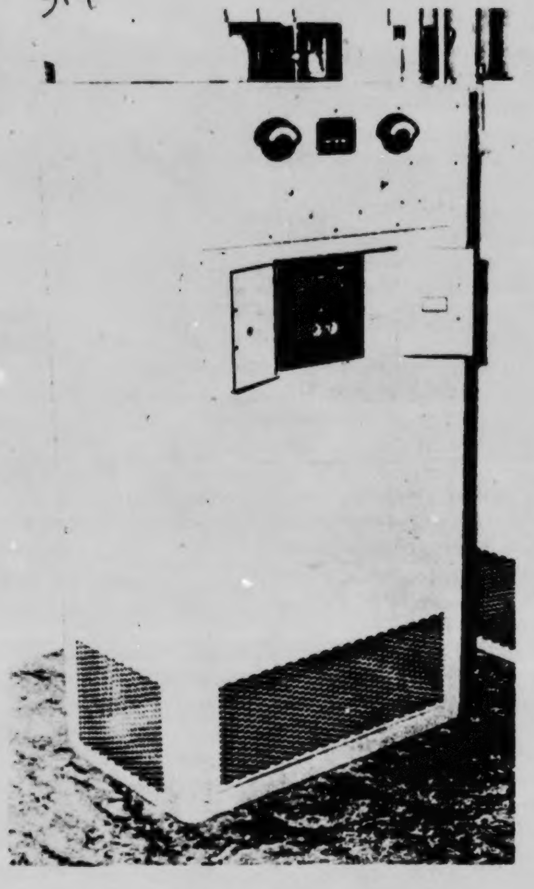


Figure 4-5. Flotrol for telephone system.

commutator or slip rings with heavy pressure to remove surface deposits and to produce a polish on the surface of the metal. When the outer layer of canvas becomes badly worn or too dirty for further use, it can be cut away and the next layer exposed.

Two channels of tones are provided by an Alnico permanent magnet-type generator without the use of brushes or commutators. Therefore, it does not require maintenance in the field. The inductive windings of the alternator produce a tone of 600 cycles per second modulated at 120 CPS, which is used for dial tone.

The interrupter is driven by the tone alternator from precision cut cams. On an "A" mounted over the motor are five slow-speed ringing interrupters, one busy tone and one all-trunks-busy interrupter, and TIME 1 and TIME 2 interrupters (used with alarm circuits). All the interrupters, when operated, have a ground potential.

Exercises (426):

1. State the purpose of the power equipment.

2. State the purpose of the ringing equipment.

4-5. Power and Ringing Equipment Circuit Operation

While there is not much to the way that the power circuits operate, you should have a basic idea about how the power that runs your exchange is produced and controlled.

The ringing machine control circuit is not only necessary in a central office, it's interesting.

427. Using foldout 5's schematic diagrams, and figures 4-5 and 4-6, determine the actions that occur in the ringing equipment during its operation and state the purposes and functions of the power equipment.

Principle of Battery Charger Operation. A single-phase rectifier is used as a source of reference voltage, and it, together with saturable reactors, regulates the output voltage, holding it constant, with variation in input voltage and variation in load.

A block diagram, figure 4-6, illustrates the operating principle of the three-phase charger, showing a power rectifier energized from a power transformer through saturable control reactors. The output of the power rectifier is filtered and supplied to the battery.

Reference voltage source. The output of the reference voltage source is connected in parallel with the output of the charger through windings on the control reactors. When the output voltage of the Flotrol drops below the reference voltage, current flows through the control reactor windings and restores the output voltage to normal. If the output voltage rises above normal, the current decreases and causes the reactors to insert more voltage drop between the power transformer and the rectifiers, thereby dropping the output voltage of the charger back to normal. This action automatically compensates for changes in input voltage, changes in load current, and changes in rectifier resistance.

Overload protection. The three-phase Flotrols are provided with a current limiting feature, an overload protection rectifier, seen in figure 4-6, which protects the charger against overloads. In case the charger is connected to a dead battery, the battery is rechanged at the maximum safe rate without danger of damage to the Flotrol.

The power transformer is fed through current transformers, which are loaded with capacitors. The voltage drop inserted between the powerline and the power transformer by these current transformers is very small. The secondary voltage of the current transformer is directly proportional to the load

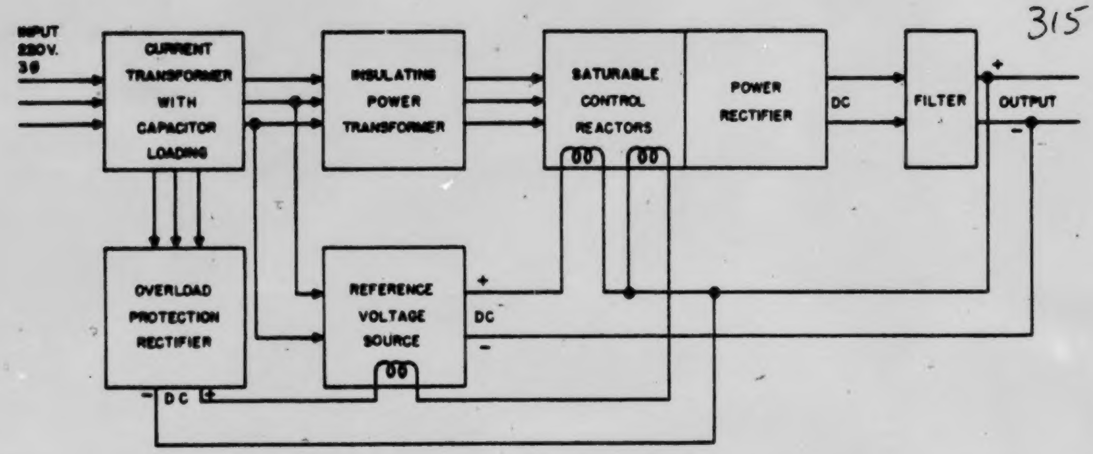

INPUT
220V.
3Ø
CURRENT TRANSFORMER WITH CAPACITOR LOADING
INSULATING POWER TRANSFORMER
SATURABLE CONTROL REACTORS
POWER RECTIFIER
DC
FILTER
+
OUTPUT
−
OVERLOAD PROTECTION RECTIFIER
REFERENCE VOLTAGE SOURCE
+
DC
−
−
DC
+

Figure 4-6. Block diagram for Flotrol operation.

current. A rectifier connected to the secondary of the current transformer develops voltage directly proportional to the load current and serves as the overload protection rectifier. The output of this rectifier is also connected in parallel with the output of the charger, through control windings.

As long as the current delivered by the charger is less than 120 percent of rated output, the voltage developed by the overload protection rectifier is less than the output voltage of the charger, and no current flows through the overload rectifier circuit. This circuit includes windings on the reference voltage source and the overload windings on the saturable control reactors, as figure 4-6 shows. As soon as 20 percent overload current is reached, the voltage developed by the overload protection rectifier begins to exceed the output voltage of the charger, and then current flows through the control windings, which are in the circuit of the overload protection rectifier.

The action of this current on the reference voltage source is to drop its voltage and thereby drop the output voltage. The same current flows through the overload windings on the saturable control reactors to unsaturate the reactors. The current flow through the overload windings of the saturable coreactors produces a flux within the core which is opposite to that developed by the normal windings. This results in desaturation of the cores, causing the reactance of the normal windings to increase, thereby limiting the ac voltage applied to the power rectifiers to a safe value.

Voltage output adjustment for battery cells. Both the power transformer and the reference voltage source are provided with taps, so that the output voltage of the Flotrol can be adjusted according to the number of cells in the battery. The B-model Flotrols are adjustable for operation of end cells. On all connections, the operation of an equalizing switch readily changes the output voltage to a higher level for equalizing the batter. The equalizing switch, figure 4-7, simply changes the output voltage of the reference source. It thereby causes the charger to regulate at a higher level.

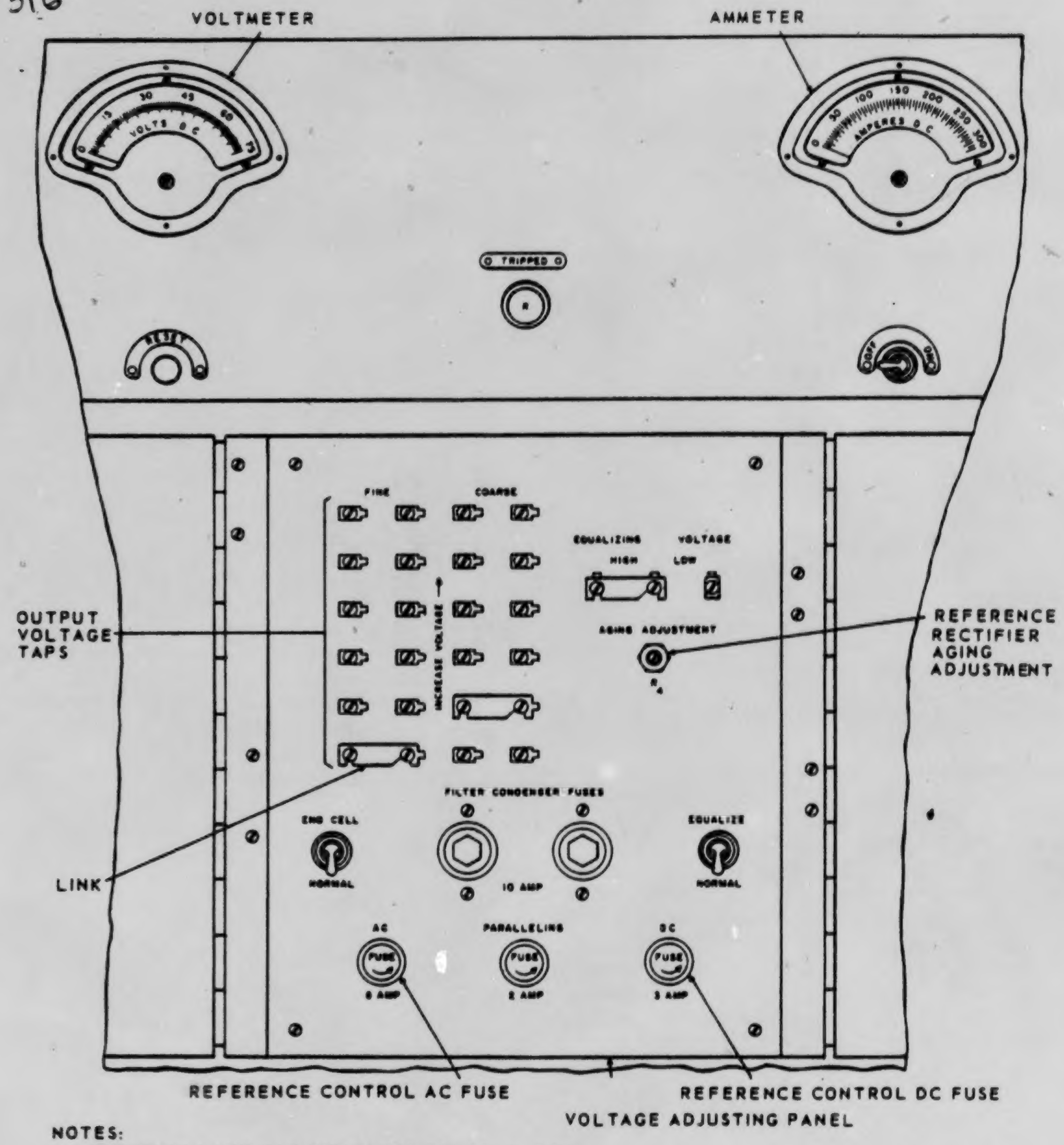
Aging. Because the output voltage is determined by the reference voltage source, aging of the power rectifier or changing of temperature of the saturable control reactors do not affect the output voltage of the Flotrol. Either of these conditions, occurring singly or in combination with changes of load or of input voltages, is automatically compensated for by changes in the output current of the reference voltage source.

It is possible for changes in the characteristics of the reference rectifiers to change the output voltage slightly, but these rectifiers are oversized and operate at much less than rated current. However, an aging adjustment is provided to take care of this possibility, as figure 4-7 reveals.

Contactor. The chargers are provided with dc contactors, so that whenever the power is off, the circuit to the battery is opened. They also have magnetic contactors on the ac input side so that the charger can be operated by remote control.

Filtering. All three-phase Flotrols are provided with a heavy duty filter choke, which eliminates the noise from the battery and talking circuit. They are also provided with electrolytic condensers, which are connected to the rectifiers and further reduce the noise to a very low level. These condensers are actually the only components which should be considered as expendable. However, their action is only one of filtering, and they can even be removed from the circuit completely without affecting the regulation of the charger.

Furthermore, in most installations where automatic switches are operated from the battery, the noise produced by the charger without the condensers is of a lower level than the switching noise across the battery, and even in case of a complete failure of the condensers, the operation of the exchange will be undisturbed. The condensers are provided with



NOTES:
1. LETTER ON LAMP CAP INDICATES COLOR; R, RED.
2. FRONT PANEL DOORS ARE OPEN.

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Figure 4-7. Typical Flotrol control panel.

protective fuses, so that in case of trouble, the fuses will blow and remove the condensers from the circuit.

Output voltage adjustment. Turn off the Flotrol while making adjustments. Each charger is provided with a voltage adjustment panel consisting of coarse and fine voltage taps by which the charger voltage may be accurately adjusted to the desired level, as figure 4-7 shows.

These taps adjust the reference voltage standard which controls the charger. The adjusting links are moved up *to increase* the voltage, *downward to reduce voltage.*

Readjustment of the rheostat (R-4) may be required if the coarse voltage tap is changed or after aging of rectifier No. 2 (reference voltage source) is experienced. Aging of the power rectifier stack is automatically compensated and requires no manual aging adjustment. Do not overcorrect, or the Flotrol output will not properly follow the load.

Equalizing voltage adjustment. The equalizing voltage can be adjusted independently of the floating voltage, as figure 4-7 illustrates. The equalizing voltage is adjusted by an equalizing voltage adjustment potentiometer located near the aging potentiometer on the voltage adjustment panel. Turning the potentiometer to the right increases the equalizing voltage. The range of equalizing voltages is from 0 to .18 volts per cell above float voltage.

Flotrol Operation. A three-phase Flotrol without any special auxiliary equipment can be operated in parallel with a dc generator across a battery. Within its capacity, the Flotrol will maintain the battery voltage constant as determined by the Flotrol characteristic.

Floating voltage. The floating voltage for the lead-acid type storage battery is generally considered to be between 2.15 and 2.17 volts per cell. Variation in floating voltage may exist between batteries. In order to determine the correct floating voltage for a given battery, you should check the specific gravity and water consumption of the batteries over a period of a month. If the gravity readings are gradually falling, the floating voltage should be increased until the gravity ceases falling for a period of one month. If the batteries require the addition of water more than once in every 3 months, the floating voltage is too high and should be reduced.

Equalizing. In order to maintain equal voltages on all cells and to fully charge the weakest cells, it is customary to periodically supply a higher voltage to the battery for a short time in accordance with the battery instructions. When the equalizing switch on the Flotrol is operated, the Flotrol delivers its maximum charging current until the battery reaches the equalizing voltage. The Flotrol then automatically holds the battery at the equalizing voltage until the switch is manually returned to its normal position. The battery should not be charged any longer than necessary at the equalizing voltage, because continued charging at this voltage may decrease the life. The charger does not have to be turned off to operate the equalizing switch.

End-cell charging. Three-phase Flotrols have an end cell voltage adjustment, which consists of a toggle switch "end cell charge" by which the output voltage can be increased by approximately 6.5 volts in order to permit charging of end cells.

Parallel operation. Some Flotrols are equipped with paralleling rectifiers operated from the current transformers. By balancing the voltage of the paralleling rectifier in one Flotrol against that in another through a portion of their control circuits, proportional division of load current between the two Flotrols is maintained even though the Flotrols may not be of the same size. Two or more Flotrols of this type are synchronized simply by installing a light gauge equalizing wire between them. If the Flotrols are not both equipped with paralleling rectifiers, satisfactory division of load current can be maintained by the use of separate charging leads for each Flotrol.

DC Disconnect. The output circuit of the Flotrol is equipped with a dc disconnect contactor. This contactor is not a reverse current relay, neither does it have any other marginal features. It is simply a heavy duty dc contactor operated from the ac power supply with sufficient time delay to insure that the circuit will not be opened while current is passing through the contacts. It will be recognized that even if the dc circuit were not opened by the contactor, the reverse current through the Flotrol would be blocked by the back resistance of the rectifiers. Nevertheless, in order to completely eliminate the possibility of leakage current and, at the same time, to provide interlocking overload protection between the ac and dc circuits of the charger, the dc contactor is provided. When the ac power fails or is disconnected, the delay of the dc contactor is sufficient to permit the direct current through the output circuit of the Flotrol to fall to zero before the circuit is opened. With this arrangement, there is no sparking whatsoever at the contacts of the dc contactor, and no maintenance is required to keep the voltage drop through these contacts to a negligible quantity.

Common Questions About Flotrols. Certain pertinent questions about Flotrols seem to be asked with great regularity. For this reason, these questions and their answers are repeated here:

(1) What happens when a flotrol is single phased? The application of single-phase voltage to a three-phase Flotrol as a result of partial failure of the incoming power cannot damage the rectifiers or transformers. Depending upon which phase fails, the result is either a complete or a partial loss of output from the Flotrol. In some cases, the fuses which protect the filter condensers may blow, protecting these condensers against excessive ripple current resulting from unbalanced input voltages.

(2) What happens on low input voltage? The output voltage of the Flotrol is completely compensated for input voltage variations of plus or minus 8 percent of the normal value. However, the input voltage can usually drop as far as 20 percent below the normal voltage without causing a complete failure of charging current. The output voltage will still be regulated to a fair degree of accuracy, but with such an abnormally low input voltage that the maximum current available from the Flotrol will be considerably less than the rated current. Still further reductions in the input voltage may result in chattering or other unsatisfactory operation of the magnetic contactors in the Flotrol.

(3) What happens when the ac power fails? When the ac power input to the Flotrol fails, the charger is automatically disconnected from the battery, and there is no possibility of leakage current through the charger

draining the power from the battery. When the power returns, the Flotrol automatically resumes its charging functions. Even if the battery has been completely discharged, the output current of the Flotrol will not become excessive but is limited by the overload protection feature.

(4) What is the expected life of the Flotrol? All of the component parts of the Flotrol are carefully designed to provide trouble-free operation and long life. The only item in the Flotrol which can be considered as expendable is the electrolyte condenser bank, which has an anticipated life of approximately 7 years. The selenium rectifiers are of highest quality and ultra-conservative design; the probability of early failure has been reduced to a negligible factor. A rectifier life can be anticipated as in excess of 15 years.

(5) What is the effect of frequency variation? Noticeable line frequency variations are rarely encountered in the U.S., but when they do occur, their effect is to change Flotrol voltage about 1.8 percent for each 1 percent change in frequency. Where frequency variation is a problem, a frequency compensation unit can be added (mounted externally) to correct for frequency variations up to ± 2 cycles.

Ringing Generator Control Circuit. The control circuit components, seen in foldout 5, are located on the power panel and consist of the following:

Keys. Ringing machine test key (R.M. TEST) is used to test the operation on one ringing machine without interfering with the operation of the other machine. Ringing machine start key (R.M. START) must be in the operated position to start the ringing machine to be used. Ringing machine alarm cutoff key (R.M. ALARM CUTOFF) cuts off the alarm while a trouble is being cleared. The reset key (R.M. ALARM RESET) resets the control relays after a trouble has been cleared.

Lamps. Generator off lamp (GEN OFF) shows when ringing machines have stopped. Ringing machine transfer lamp (R.M. TRANSF) shows when there has been a transfer from one machine to another.

Relays. D21 is normally operated from direct generator. D22 lights R.M. TRANSF lamp and operates the dc contactors for automatic operation. D23 operates when the START KEY AND RESET KEY are operated for machine 2. D24 completes the path for the transfer relays. D25 transfers the generator control leads from machine 1 to machine 2. D26 transfers the busy tones from machine 1 to machine 2. D27 transfers the dial tone from machine 1 to machine 2. D28 transfers the direct generator (ringing current) from machine 1 to machine 2. DC contactors complete a path to start the dynamotors.

Manual Operation for Ringing Machine 1. The R.M. START KEY, also seen in foldout 5, is in the 1 position. Ground from R.M. START KEY operates the dc contactor for R.M. 1. DC contactor extends ground through winding of the field and motor of the dynamotor to battery. Dynamotor 1 starts. When relay D-21 operates, the collector rings of the dynamotor extend direct generator (19 Hz ac) and battery to the ring control relay contacts and the ac relay D-21. This opens the operating path for D-22. D-21 is the only relay operated while ringing machine 1 is running. The cams on the tone alternator interrupt ground for the busy tones at contacts 1T and 2T and 7T and 8T of relay D-26. Ground is interrupted by the cams for the ring control relays through the contacts of relay D-25.

Automatic Transfer from Machine 1 to Machine 2. If ringing machine 1 stops generating ringing current, ringing machine 2 starts automatically. Then these things happen:

a. Relay D-21 releases. Relay D-21 releases when the direct generator is removed. Numbers 1 and 2 are not contacts, but terminals for the windings of relay D-21. Number 3 and 4 contacts complete an operating path for D-22. Number 5 and 6 contacts complete a path for the GEN OFF light.

b. Relay D-22 operates. Number 2 and 3 contacts complete an operating path for D-24. Number 4 and 5 contacts complete a path for the R. M. TRANSF lamp. Number 6 and 7 contacts complete a holding path for D-22. Number 8 and 9 contacts complete a path to dc contactor 2, making it an automatic transfer.

c. DC contactor 2 operates. Ringing machine 2 starts.

d. Relay D-24 operates. Number 1 and 2 contacts complete a path for D-25. Number 3 and 4 contacts complete a path for D-26. Number 5 and 6 contacts complete a path for D-27. Number 7 and 8 contacts complete a path for D-28.

e. Relay D-25 operates. Number 8B and 9B, 5B and 6B, 2B and 3B, 8T and 9T, 5T and 6T contacts provide a path for interrupted ground from R. M. 2 on GEN CONT leads 1 through 5 to the ring control relays D-4 through D-8 or D-14 or D-18.

f. Relay D-26 operates. Number 3T and 2T contacts provide a path for interrupted ground from the tone alternator 2 to the tone circuit.

g. Relay D-27 operates. Number 3T and 2T contacts provide a path for dial tone from tone alternator 2 to the tone circuit.

h. Relay D-28 operates. Number 6B and 5B, 9B and 8B contacts provide a path for DIR GEN from R.M. 2 to relay D-21 and ring control relays. When machine 2 starts, the direct generator reoperates relay D-21.

i. Relay D-21 operates. Number 3 and 4 contacts open the operating path for D-22. Number 5 and 6 contacts remove the ground from GEN OFF light.

NOTE: When the alarm rings, you should switch the R.M. START KEY from 1 to 2 and operate the RESET KEY. D-22 will release, and D-23 will operate from ground at the RESET KEY.

j. Relay D-22 releases. Number 1 and 2 contacts provide a holding ground for D-24. Number 4 and 5 contacts remove the ground from R. M. TRANSF lamp and central office alarm. Number 6 and 7 contacts open the holding path for D-22. Number 8 and 9 contacts remove the ground from dc contactor 2.

k. Relay D-23 operates. Number 2 and 3 contacts provide a holding path for D-24. Number 5 and 6 contacts prepare a path for D. C. contactor 1. Number 7 and 8 contacts provide a holding path for D-23.

All relays, except D-22, are operated when machine 2 is running.

Generator Control and Transfer Relays. The RING RLYS TRANSFER key determines which ringing circuit is in operation. In position 1, the 1 circuit is used. Relays D-1, D-2, D-3, D-9, and D-10 have an operating path from the key contacts. These things occur:

a. Relay D-1 operates. Number 1T and 2T contacts prepare a path for D-4. Number 3T and 4T contacts prepare a path for D-5. Number 5T and 6T contacts prepare a path for D-6. Number 1B and 2B contacts prepare a path for D-7. Number 3B and 4B contacts prepare a path for D-8.

b. Relay D-2 operates. Number 1B and 2B contacts open the operating path for D-11, D-12, and D-19 in circuit 2. Number 3B and 4B contacts provide a holding path for D-1, D-2, and D-9 in circuit 1. The other make contacts prepare a path for direct generator or negative battery.

c. Relay D-3 operates. Number 1B and 2B contacts open the operating path for D-13 and D-20. Number 3B and 4B contacts provide a holding path for D-3 and D-10. The other make contacts prepare a path for direct generator or negative battery.

d. Relays D-4, D-5, D-6, D-7, and D-8 operate. These relays operate in numerical sequence (D-4 through D-8) to provide 1 second ringing and 4 seconds silent period. DC battery is required for the cut through relay in the connector. The dc battery is furnished through the direct generator path during ringing, and through contacts 1 and 2, 4 and 5 during the silent period. Number 2 and 3, 5 and 6 contacts complete the direct generator path.

e. Relay D-9 operates. Number 1T and 2T, 3T and 4T, 5T and 6T, 1B and 2B, and 3B and 4B contacts prepare a path for the direct generator.

f. Relay D-10 operates. Number 1T and 2T, 3T and 4T, 5T and 6T, 1B and 2B, and 3B and 4B contacts prepare a path for the direct generator.

Dial Tone. This tone is generated by the tone alternator with either ringing machine operating. This tone goes from the tone alternator through the contacts of relay D-27 to the tone circuit. In the tone circuit, the tone (ac) goes to the primary of the dial tone transformer on the selector shelf. The SUPY relay on the selector shelf operates in series with the B relay of the selector, closing the contacts of the SUPY relay. The tone is induced into the secondary of the transformer and is extended through the selector to the calling subscriber.

Busy Tone. Regular busy tone is dial tone interrupted 60 impulses per minute. The dial tone flows through resistor R-4, capacitor C-1, and coil BT-1. This tone is induced into the secondary winding of BT-1. When the busy tone cam on the interrupter closes the contacts, tone flows to the connector bays.

All-Trunks-Busy Tone (ATB). This tone is dial tone interrupted 120 impulses per minute. The dial tone flows through resistor R-5, capacitor C-4, and the primary winding of BT-2. This tone is induced into the secondary winding of BT-2. When the cam on the interrupter closes the contacts, a ground shunt is present. Tone is sent to the selector bays only when contacts are open.

Exercises (427):

1. How is the reference voltage source of a battery charger connected in the charger circuit?

2. What is the purpose of the control reactors?

3. What is the overload current of a Flotrol considered to be?

4. What does the equalizing switch on a Flotrol do?

5. What is the purpose of the dc contactors in the battery charger?

6. What does the filter choke in a charger do?

7. How do the output voltage adjustment taps work?

8. What indicates to you that the float level is set too high?

9. What relay in the ringing generator is normally operated from direct generator?

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10. What do all of the interrupter's cam contacts have in common?

11. What would happen first in the control circuit (FO 5) if ringing machine 1 stops for some reason?

12. What is common about relays D-4 and D-14 in the generator control circuit (FO 5)?

13. What is the difference between busy tone and all-trunks-busy tone?

4-6. Troubleshooting Power and Ringing Equipment

A central office without power or ringing equipment that works is in worse trouble than a man who smokes and has no cigarettes and matches.

428. Given selected power and ringing equipment trouble symptoms and appropriate situations, as well as foldout 4 and 5's schematic diagrams, and figures 4-1 to 4-7 as required, determine the probable causes of trouble and state the corrective action needed for each situation.

Assume that ringing machine 1 fails and that no automatic transfer to machine 2 takes place. Barring an open winding somewhere, the possibilities number four.

First, relay D-21 releases, closing its 3 and 4 contacts. This completes the path from battery through the winding of relay D-22 to ground on the contacts of the reset lever switch. Your first move then is to look at relay D-22. If it is not operated, contacts 3 and 4 of released relay D-21 or contacts of the RESET switch are at fault. If it operates, then its 8 and 9 contacts or the 4 and 5 contacts of D-23 are at fault.

Exercises (428):

1. What is the trouble and the necessary corrective action when you must add water to most battery cells every month?

2. One connector shelf does not have ringing current. Relays D-1, D-2, D-9, and D-25 are operating properly and their contacts are clean and making properly. What is the trouble and what is the corrective action?

3. The connector shelf served by group A of ring control relay's circuit 1 does not trip ringing between ringing cycles. What is the cause of the troubles?

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CHAPTER 5

Attendant's Cabinet and Miscellaneous Trunk and Switching Equipment

ALTHOUGH MOST of the calls we make each day are from one phone to another on base, we do have a need to call the operator, fire department, another base, etc. on occasion. Since this equipment is located in your exchange and it is important, when needed, this chapter discusses briefly some of these circuits.

We also spend some time looking at the attendant's cabinet, because it is also an important function within our exchanges.

5-1. Miscellaneous Trunk and Switching Equipment Description

In this section, we discuss the purpose and functions of the pulse repeater, fire trunk, and the reverting call switch. These are some of the circuits that make up the miscellaneous trunk and switching equipment in your exchange.

429. Give the purpose or function of each of several specified pieces of trunk and switching equipment, ranging from the fire trunk and reverting call switch through access to the pulse repeater and the fire repeater and reverting call switch to the pulse repeater's function.

Fire Repeater. The fire repeater and its associated bell provide a means of connecting a calling telephone to the base fire department. All calls to the fire alarm reporting number signal the switchboard attendant, who may or may not assist with the call or record it. The procedure followed will depend upon your base requirements.

In some installations, fire alarm calls go directly to the fire department and, also, to the fire trunk panel on the attendant's cabinet. In other installations, all fire alarm calls are answered and verified by an attendant at the switchboard. A special fire alarm number, usually 17 or 117, is assigned to the fire department telephone. If calls come in to the fire trunk because of dialing errors, the attendant can release such calls. If the fire call is genuine, the attendant extends the call to the fire department. The switch train can be held operated by the attendant, so that the call can be traced in case of incomplete information or false alarm. Now let us look at another type of repeater, the pulse repeater.

Pulse Repeater. The pulse repeater is needed to enable a telephone subscriber to call another subscriber in a distant telephone central office.

The pulse repeater, also referred to as a trunk repeater, is an all-relay switch for repeating the dial pulses from one circuit to another. Pulse repeaters are used in areas that have more than one central office to complete calls from one office to another. A pulse repeater consists essentially of a group of relays mounted on a switch base. A pulse repeater is associated with each outgoing trunk from the central office.

The pulse repeater that you will study (H-61678) is used when the trunk resistance is 2000 ohms or less. If the distant central office is so far away that the trunk resistance is over 2000 ohms, another type of pulse repeater must be used.

The pulse repeater is accessed from the banks of a selector switch or from a switchboard jack appearance. Most commonly, the digit 9 is dialed into the selector to seize the pulse repeater. After it has been seized, it returns dial tone from the distant exchange to the calling subscriber. The subscriber then dials the first digit of the desired number. The pulse repeater repeats the dial pulses by reducing the trunk resistance to the distant exchange. The digit is routed through a pulse repeater in the distant exchange into an incoming selector switch, which steps to the pulses of the dial. That selector cuts through to another selector or connector, which accepts the rest of digits to the called number.

Not all of the miscellaneous trunk and switching equipment in an exchange is for the subscriber. There are some items to assist the maintenance types, one of which is the reverting call switch.

Reverting Call Switch. The reverting call switch is an all-relay switch which enables installation and maintenance personnel to ring the telephone on which they are working by dialing a special number which provides access to a reverting call switch. The reverting call switch consists of a group of relays, resistors, busy switch, and a test jack mounted on a switch base. The

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switch is jack mounted to allow easy removal for adjustment and repair.

There are usually two reverting call switches in the typical military installation. The switches are connected to the first two bank contacts of level 9 of the special second selectors. If the first reverting call switch is in use, the next special second selector stepped to level 9 will step across to the bank contacts to which the second reverting call switch is connected.

After dialing the digit 9 into the special second selector, the installer then replaces the handset on the cradle. The telephone rings until the installer picks up the handset to stop the ringing. He then hangs back up to release the equipment.

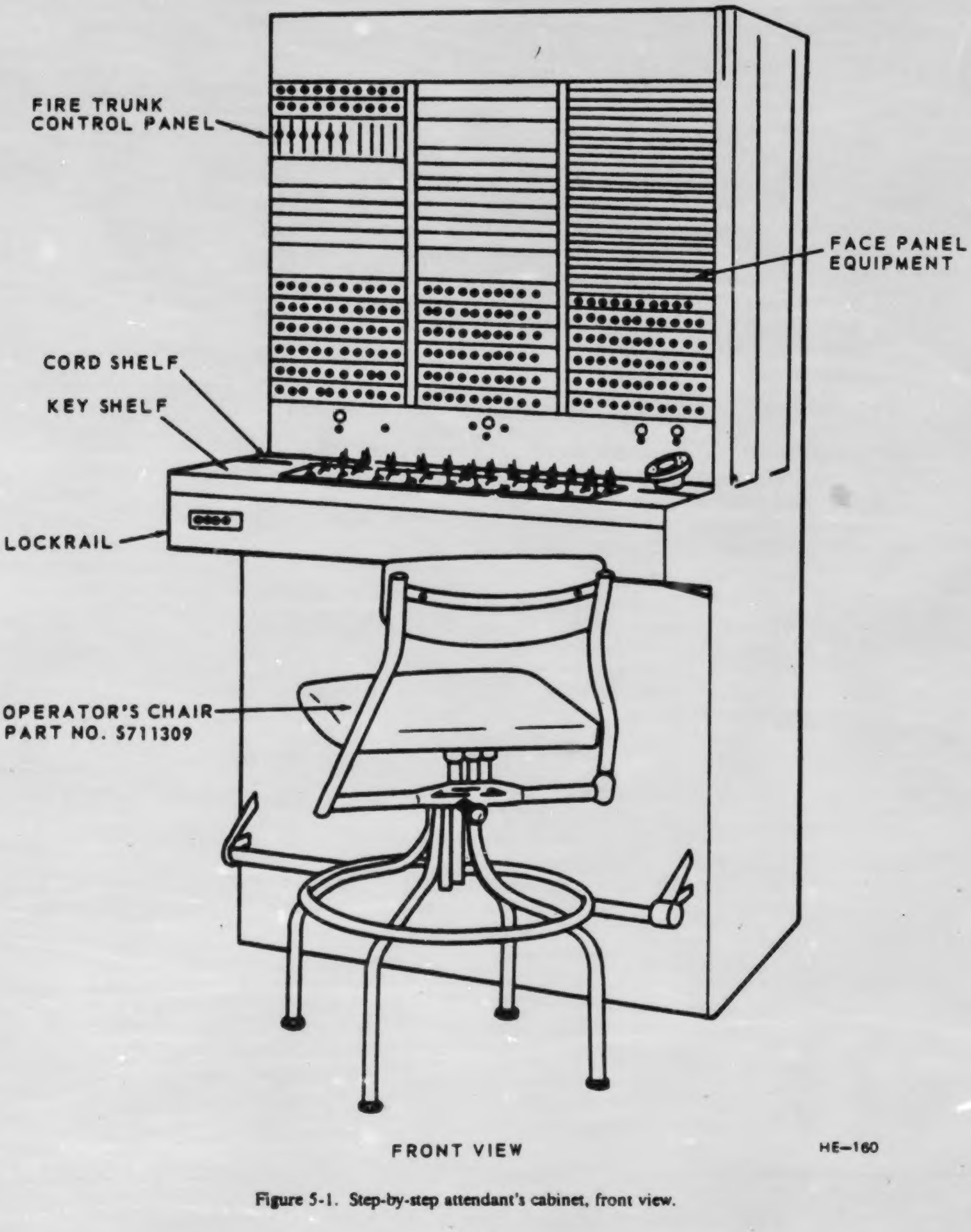

Figure 5-1. Step-by-step attendant's cabinet, front view.

Exercises (429):

1. What is the purpose of the fire repeater?

2. What is the main function of the reverting call switch?

3. How is the pulse repeater accessed?

4. What are the main functions of a pulse repeater?

5. How are the fire repeater and reverting call switch accessed?

5-2. Attendant's Cabinet Description

The attendant's switchboard (cabinet) of a step-by-step dial central office provides services that supplement those provided by the automatic switching equipment. These services are given by one or more attendants. They include service as a telephone information center, the completion of calls between dial telephones and the nondial telephones (common battery and magneto) associated with the exchange, the completion of calls to and from some other central offices, and some types of special services. They also assist the fire department in validating and tracing fire calls when the point of origin is not given.

430. State the functions and operation of the attendant's cabinet and its associated circuits.

Attendant's Cabinet. The attendant's cabinet, shown in figure 5-1, is a switchboard consisting of one or more positions. A position is that part of the switchboard one operator mans. The position is divided into one to three panels. The number of positions depends upon the maximum expected calling rate and is determined by the engineers. The attendant's cabinet that serves an automatic exchange may also serve manual subscribers.

All manual subscribers (CB and LB) have an incoming line jack appearance, while subscribers served by an automatic exchange do not. When a dial subscriber desires to reach the operator, he may do so over the information trunk which is seized by dialing 13 or 113, or over the operator's trunk by dialing zero.

The operator may reach any telephone served by the office through the use of the out-dial-to-line equipment or out-dial-to-connector trunks. The manual subscribers may be reached by the operator through their line jack appearances. The operator may reach another attendant's cabinet through trunks that are terminated on the switchboard. The subscribers do not have access to these trunks. The operator may also access the common trunking equipment from the out-dial-to-line equipment.

Relay gate. The circuit apparatus for the cord circuits, the operator's position circuit, and the attendant's telephone circuit are mounted on a hinged steel gate at the back of each switchboard position.

Key shelf and cord shelf. The horizontal portion of each basic switchboard position contains the cords, the supervisory lamps, the lever switches for the 17 cord circuits and those associated with the operator's

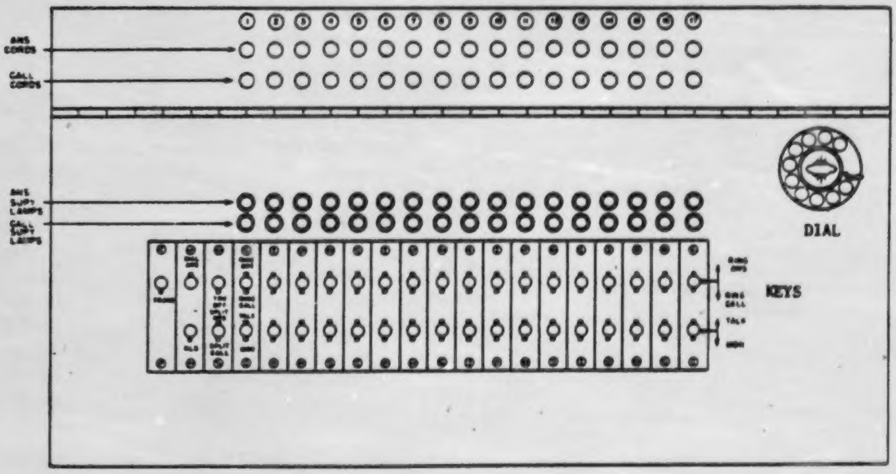

Figure 5-2. Key shelf and cord shelf of attendant's cabinet.

position circuit, and a dial, as revealed in figure 5-2. This equipment, together with the relays mounted on the relay gate, make up the 17 universal cord circuits. Each cord circuit contains a talk-monitor lever switch (TALK when the switch is operated toward the rear of the switchboard, and MON when the switch is operated toward the attendant) and the ringing lever switch (RING on the *answer* cord, when the switch is operated toward the rear of the switchboard, and on the call cord, when the switch is operated toward the attendant). Lever switches (keys) for the cord and the operator's position circuits are mounted on a key shelf shown in figure 5-2.

NOTE: The term "lever switch" (sometimes shortened to switch) is the official terminology for the component often described by telephone personnel as a "key." Throughout this course, the terms "lever switch", "switch", and "key" are used interchangeably.

Relay racks. The circuit apparatus associated with the magneto lines, the common battery lines, and the incoming trunks from selector levels are mounted on relay racks; these racks are installed in the switchroom. The relays and the the other circuit apparatus used with central office (city) trunk and with auto-to-auto trunks are part of the pulse repeaters associated with these trunks; these repeaters are also installed in the switchroom. The relay racks are placed near the TIDF (trunk intermediate distributing frame) in order to minimize the length of interconnecting cables. Fuse panels at the top of each rack hold the fuses that protect the equipment mounted on that rack. The line and trunk equipment circuits terminate at terminal boards on the back of each bay.

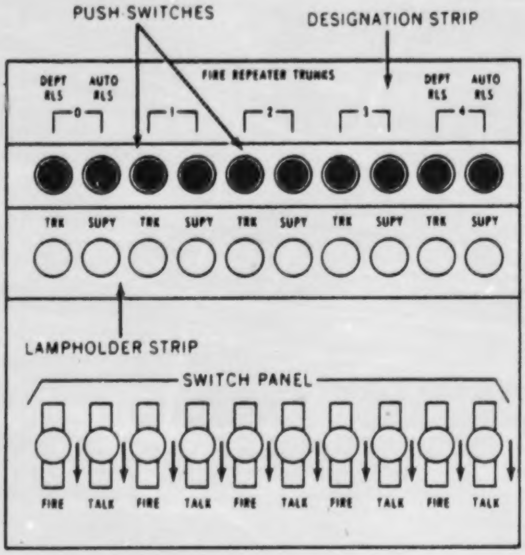

Figure 5-3. Fire trunk control panel.

Fire trunks. Control equipment for fire trunks, seen in figure 5-3, is located at the top of the left-hand panel of position 1 of a typical attendant's switchboard. Such equipment includes a push-switch assembly, a lampholder strip, and an assembly of lever switches.

Face equipment. The face equipment of an attendant's switchboard contains designation strips, strips that hold line and busy lamps, and blank spacers. Special switch panels, such as the fire control equipment, are sometimes included. There is no standard layout for the face equipment. Each switchboard will contain the equipment needed to fulfill its specific requirements. The manufacturer's drawing will show jack panel equipment and auxiliary pilot and control apparatus, which is located below the jack panels.

A night alarm circuit is provided as part of a typical attendant's switchboard. This circuit is usually located in position 1 of multiposition switchboards. The night alarm circuit contains a buzzer, so that incoming calls will give audible (as well as visual) signals when the circuit is in operation; such signals are used during periods of light traffic. A night-alarm switch, located beneath the jacks on the right-hand panel of the position, permits the attendant to disconnect the night-alarm circuit during periods of normal and heavy traffic.

Multipling. All of the lines and trunks (except the fire trunks) connected to the switchboard are multiplied to each switchboard position, so that each attendant has access to all lines and trunks. Short lengths of cable are used to connect the jack strips and lampholders strips of switchboard position 1 with corresponding strips of switchboard position 2, etc.

Services Within the Exchange. The attendant's switchboard serves primarily as an information center and to render assistance in emergencies, such as fire calls. The attendant's switchboard also handles calls between dial and nondial telephones, and calls to and from city or other central offices when trunk circuits for this purpose are provided. Following are some typical services that are provided by the attendant's switchboard for telephones served by the dial central office.

Typical attendant's switchboards are equipped with trunk circuits from the selector 0 level. These are used to answer calls from dial telephones when 0 is dialed for assistance or toll service. Call, recall, and disconnect supervision are supplied by lamp signals.

The attendant can extend calls that reach the switchboard on the information and operator's trunks to nondial telephones, or to city or manual central offices, by means of the cord circuits and the out-dial or other trunk circuits.

The attendant answer calls from magneto lines (used for special services in some offices) and extends calls to dial telephones or to outgoing trunks, as required. Call, recall, and disconnect supervision are effected from the magneto telephone by ringing on the line. Calls from regular dial telephones also are extended to magneto lines, with normal lamp supervision on the calling line. Manual ringing on the magneto lines is required; a RING switch is provided in the cord circuit.

The attendant's switchboard also handles calls from and to common battery nondial (manual) telephones; nondial telephones are sometimes used as part of a dial system, for certain cases in which dial service is not used. Normal lamp supervision is received from a common battery line through operation of the telephone hookswitch. Calls from these lines are extended to other telephone lines or to city or manual central offices.

The attendant handling fire-alarm calls may verify the calls and extend them to the fire department through the fire-control panel mounted on the first position, shown in figure 5-3. Fire calls are dialed from station lines by dialing a special number, usually 117. This extends the call through the special second selector and operates the fire repeater, sounding an alarm in the switchroom and sounding a buzzer and lighting a lamp on the attendant's switchboard fire-control panel. The attendant then verifies the call, sends the alarm to the fire department, and transfers the calling telephone to the fire department line. The attendant has supervision over release of the equipment and can hold the switch train of the calling line operated to permit tracing the call to its source, if need be.

Services to Other Central Offices. When the dial central office has trunk circuits to other central offices, either automatic or manual, calls to these offices from telephones not authorized to dial them directly are handled through the attendant's switchboard. Telephones that wish to reach such central offices dial the switchboard on the information trunk circuit. For calls to manual offices, the attendant relays the call to the operator at the manual office. For calls to dial offices, the attendant may dial the desired number directly. Disconnect supervision is received from the calling line. Toll calls can be timed and recorded by the attendant. Delayed calls can be handled; the attendant notifies the calling telephone when the desired (called) line is available.

Incoming calls from other central offices may be extended by the attendant to any telephone served by the dial central office. Calls to dial telephones are completed by dialing the telephone through the out-dial-to-connector trunk circuits or the out-dial-to-line-equipment trunk circuits, or through the operator's selectors, if disconnect supervision is supplied by the called line. Ringing current is automatically supplied by the connector. A call to a magneto or a common battery manual line is completed by plugging directly into the proper line jack and ringing manually from the switchboard. Disconnect supervision is received by lamp signals from the common battery lines and by ringing from the magneto lines. No disconnect supervision is received from the outside central office, except by reringing on the trunk.

Exercises (430):

1. Which subscribers have line jack appearances on the switchboard associated with an automatic central office?

2. How many universal cord circuits are mounted on the automatic electric switchboard position?

3. By means of which two types of circuits can a switchboard operator reach any telephone served by a Strowger central office?

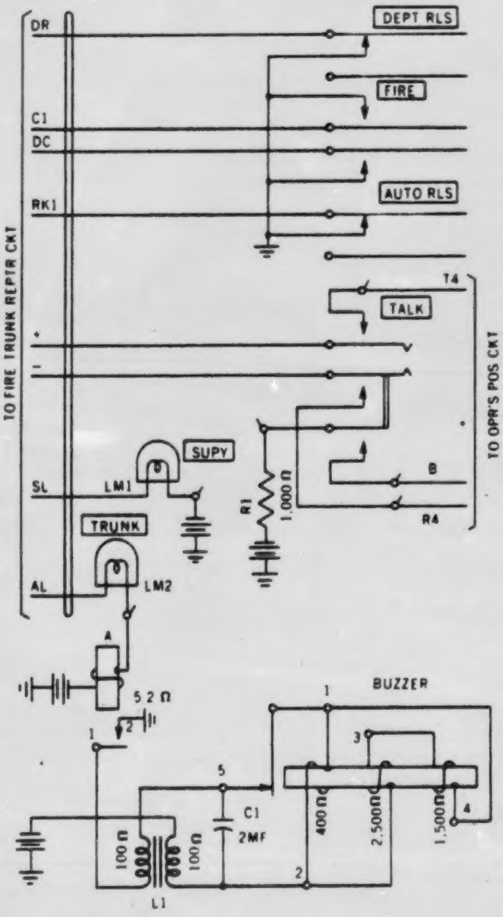

Figure 5-4. Fire trunk circuit schematic.

4. Where on the switchboard is the fire trunk control panel located?

5. What is the primary function of a switchboard in a Strowger exchange?

6. What does the switchboard operator do with respect to incoming fire calls?

7. Name four circuits that are associated with the switchboard but are not part of the switchboard circuitry proper.

5-3. Operation of Circuits

As we have mentioned earlier, the fire repeaters are mounted on the miscellaneous switching equipment shelf in the switchroom. Figure 5-3 illustrates a fire trunk control panel used on a typical attendant's switchboard. Figure 5-4 is a circuit schematic of the fire trunk control equipment, showing one trunk circuit. There is one trunk circuit for each fire repeater and one relay and alarm buzzer which is common to all trunks. The line AL or trunk lamps LM2 are multipled through relay A so that the buzzer will sound for a fire call on any trunk. A functional diagram of the fire repeater and fire trunk control apparatus is shown in foldout 6 (in separate enclosure).

431. Using foldout 6's schematic diagram, specify the actions that occur in the fire repeater during operation involving certain specified portions of the equipment as typically employed.

Dialing a Fire Call. Subscribers at dial telephone stations place fire calls by dialing the number 17 or some combination of digits ending in 17. This extends the call through the first selector and the special second selector to an idle fire repeater. Relay A in the fire repeater operates, grounding the release trunk through the AUTO RLS switch and completing a circuit to the winding of relay K (FO 6). The selectors and linefinder used by the calling line are held operated by ground on the release trunk (RLS TRK). Relay K operates, lighting the trunk line lamp (over lead AL) on the fire control panel at the attendant's switchboard. Current for the lamp flows through the winding of relay A, seen in figure 5-4, of the attendant's switchboard, operating it and closing the circuit to the buzzer and also giving an audible alarm signal to the attendant.

Extending Call to Fire Department. To answer the call, the TALK switch (on the fire control panel) is operated. This connects battery through resistor R1 to lead B in the operator's position circuit of figure 5-4 and connects the attendant's headset across the fire trunk. To extend the call to the fire department, the FIRE switch is operated momentarily, grounding leads C1 and DC. Ground on lead C1 operates relay G in the fire repeater (FO 6), which locks to ground on lead DR from the DEPT RLS switch and connects the +TRK1 and −TRK1 leads of the trunk to the fire department, to ground, and to the 200-ohm winding of relay F. Ground on lead DC operates relays B and D in the fire repeater. Relay B locks to ground on lead RK1 from the AUTO RLS switch to hold relay D operated, connect interrupted ringing current (INTRPTED GNRTR) through capacitors C3 and C1 to the line—as ringback tone for the calling party—and connect noninterrupted ringing current (DIRECT GNRTR) through the 200-ohm winding of ringing cutoff relay F to the −TRK1 trunk lead. Operation of relay D reverses battery to the calling telephone, connects direct generator to ALARM NO. 1 lead, and closes an additional path from ground at the AUTO RLS switch over lead RK1 and through contacts 6 and 7 of relay B and contacts 4 and 5 of repeater relay D to the release trunk lead to hold the preceding switch train operated independently of relay A in the fire repeater. The ringing current connected by relay B to the fire department rings the fire department telephone continuously until the fire department answers. The ringing current connected by relay D to ALARM NO. 1 lead rings the AC ringer in the switchroom to alert the switchroom personnel. Operating the fire alarm ringer switch stops the ringing. The call may be traced through the special second selector, the first selector, and the linefinder to get the directory number of the calling line. The line-record card for this number is then checked to find the location of the telephone.

Fire Department Answers. When the fire department answers, a loop circuit is closed to the 200-ohm winding of relay F in the fire repeater. Relay F operates, locks to ground on lead DR from the DEPT RLS switch, extinguishes trunk line lamp LM2 and lights supervisory lamp LM1, cuts off ground and DIRECT GNRTR from the +TRK1 and −TRK1 leads, and connects the fire department through to the windings of relay C and E in the fire repeater. Relay C operates; but with the usual wiring of the fire repeater, the break contacts of relay C are permanently short-circuited and have no effect. In some installations, operation of relay C would extinguish the supervisory lamp. Relay E is differentially wound; so it does not operate.

A talking circuit between the calling telephone and the fire department is completed through capacitors

C1 and C2. The attendant monitors across the R (−) and T (+) wires.

If the fire department disconnects and it is necessary to recall the department, the DEPT RLS switch is operated momentarily to restore relay F. This also releases relay G, however, and the FIRE switch must be operated again.

Release. When the calling telephone disconnects, relay A in the repeater restores and opens one connection between the RK1 and the RLS TRK leads (FO 7), leaving the calling switch train held by ground on lead RK1 through the 6-7 contacts of relay B and the 5-4 contacts of relay D. When the fire department disconnects, relay C restores, but lamp LM1 remains lighted. The attendant monitors the call and requires no supervisory signal to disconnect.

The attendant restores the TALK switch and then momentarily operates the DEPT RLS switch, releasing relays F and G. The AUTO RLS switch is then momentarily operated, releasing relays B, D, and K, removing ground from the release trunk, and permitting the switch train to release. When relay D restores, it disconnects ringing current from ALARM NO. 1 lead and connects it to ALARM NO. 2 lead. If the switchman had operated the fire alarm ringer switch to stop the AC ringer, the ringer would have again operated continuously until the switchman restored the switch to normal. Negative battery on the release trunk, through the winding of relay K, marks the repeater idle to the special second selector for the next fire call.

Exercises (431):

1. How many fire alarm buzzers are provided in a step-by-step telephone switching center when there are 10 fire trunks?

2. How is it possible to determine the station from which a fire call is received if the calling party terminates the call before giving all of the essential information to the attendant?

3. What step-by-step equipment unit must be supplied with a negative battery potential from the fire repeater circuit in order that the telephone switching center attendant be aware that there is a fire call?

4. What does the switchboard operator do to extend a fire call and how does it affect the trunk circuit (FO 6)?

5. What happens in the fire trunk circuit (FO 6), when the fire department answers a call?

432. Using foldout 7 as needed, give the pulse repeater's purpose and state the actions that occur and their affect on associated equipment during typical operation.

The pulse repeater is an all-relay switch used to strengthen and repeat dial pulses from one central office to another. It consists of a group of relays mounted on a switch base. Its operation is entirely electrical, since it does not have the stepping mechanism of linefinders, selectors, or connectors. There is a pulse repeater for each outgoing trunk (interoffice trunk) at the point where the trunk leaves the central office. The term "interoffice trunk," as used in this discussion, is the general classification for all trunks between central offices, dial or manual. It includes both auto-to-auto and auto-to-manual trunks.

There are two types of pulse repeaters: one-way pulse repeaters and two-way pulse repeaters. One-way pulse repeaters repeat dial pulses from a local (originating) central office over interoffice trunks to a distant (terminating) central office. This arrangement is called a one-way, pulse repeater because it permits the operation of interoffice trunks in one direction (outgoing) only. Two-way pulse repeaters, on the other hand, permit operation of interoffice trunks both from a local office to a distant office and from a distant office to the local office, over the same interoffice trunks. A one-way pulse repeater is located only at the outgoing end of an interoffice trunk in the central office in which the calls originate. A two-way pulse repeater is located at each end of an interoffice trunk, permitting the use of the interoffice trunk for both outgoing and incoming calls between the two offices.

Foldout 7 is a simplified schematic diagram of a typical pulse repeater. Referring to this circuit diagram, you will see that a three-wire trunk enters the pulse repeater at the left. This trunk consists of a positive lead and a negative lead for talking and dialing and a C lead for control purposes. It extends from the banks of preceding selector in the local central office. A two-wire interoffice trunk, consisting of a positive and a negative lead, leaves the repeater at the right (terminals 5 and 6 of PL1) and is connected to an incoming selector in the distant central office. The incoming selector is similar to the regular selector, with the exception that the incoming selector is wired to the repeater instead of to a linefinder.

Outgoing Calls. Outgoing calls reach the pulse repeater from a regular first selector or a special second selector located in the local central office. In this text, this office will be referred to as the local office, and the office to which the repeater extends the call will be referred to as the distant office.

Seizure. When the wipers of the selector in the local office seize the trunk leading to the repeater, a circuit is completed from negative battery through the lower 200-ohm winding of relay A of the repeater (FO 7), through contacts 2 and 3 of relay D, out the negative side of the calling line loop, through the closed dial pulse springs of the calling telephone, back over the positive side of the calling line loop, through contacts 5 and 6 of relay D of the pulse repeater, and through the upper winding of relay A to ground.

When relay A operates, it closes its contact 4 with contact 5 and its contact 6 with contact 7. It thus extends the dial pulse transmitting circuit to contacts 3 and 6 of relay F, as foldout 7 shows. Relay A also closes contacts 2 and 3 to complete the operating circuit of relay B. The operating circuit of relay B runs from negative battery through the winding of relay B and through contacts 3 and 2 of relay A to ground.

When relay B operates, it connects ground through its contacts 1 and 2 to the C lead of the outgoing selector in the local office to hold the switch train operated. Relay B also closes its contacts 3 and 4, completing a circuit through the 1400-ohm winding of relay D and completing the operating circuit of relay F. Relay D does not operate at this time, because the magnetic field developed by its 1400-ohm winding is not strong enough to move the armature.

Relay F operates and extends the trunk loop to the distant office to seize the incoming selector in that office and opens the circuit to the incoming selector in the local office. The circuit to the incoming selector in the local office was partly completed through contacts 1 and 2 and 5 and 4 of relay F before relay F operated. When relay F operates, these contacts open.

The trunk loop circuit is completed from negative battery through one winding of relay A in the incoming selector at the distant office, through contacts 4 and 5 of relay F of the pulse repeater in the distant office, over the negative side of the loop, through contacts 5 and 6 of relay F of the local pulse repeater (unless otherwise noted, relays referred to are in the local pulse repeater), through contacts 3 and 2 of relay C, through contacts 7 and 8 of relay B, through the 375-ohm winding of relay D, through contacts 5 and 6 of relay C, through contacts 6 and 7 of relay A, through contacts 3 and 2 of relay F, over the positive side of the loop, through contacts 2 and 1 of relay F of the pulse repeater in the distant office, and, finally, through the other winding of relay A of the incoming selector in the distant office to ground. The completion of this circuit causes relay A of the incoming selector to operate and prepare the selector to receive dial pulses.

When relay F operates, contact 8 breaks with contact 7 to open the circuit to the C lead of the incoming selector in the local office and makes with contact 9 to complete the operating circuit of relay E. This circuit extends from negative battery through the winding of relay E, through contacts 1 and 2 of SW-1 (busying switch), and through contacts 8 and 9 of relay F to ground.

Relay E operates and connects a multiple ground to the C lead and the swtich train through contacts 2 and 3.

With the loop of the calling telephone extended through the pulse repeater to an idle incoming selector in the distant office, the incoming selector is prepared to operate in response to dial pulses from the calling telephone.

Dialing. When the dial of the calling telephone is operated, the pulse train of each digit dialed is repeated by the pulse repeater over the interoffice trunk to the switches in the distant office. The first break of the dial pulse springs opens the loop of the calling telephone through the windings of relay A of the local pulse repeater.

Relay A restores and opens the loop circuit to the incoming selector in the distant office by breaking contact 4 from contact 5 and contact 6 from contact 7, and completes the operating circuit of relay C by closing its contacts 1 and 2. (The holding circuit of relay B is momentarily broken when relay A restores, but relay B does not restore, because it is a slow-releasing relay.)

When relay C operates, it opens the loop circuit to the distant office. This circuit passes through the 375-ohm winding of relay D. Relay C also connects negative battery to one side of the loop (now incomplete because relay A has restored) to the distant office and connects ground to the other side of the incomplete loop to the distant office. These two connections to negative battery and ground (completed through contacts 4-6 and 7-9 of relay C) supply the voltage required to transmit dial pulses over the loop to the distant office, as figure 5-5 reveals. Operated relay C also removes the 375-ohm winding of relay D from the loop to the distant office by

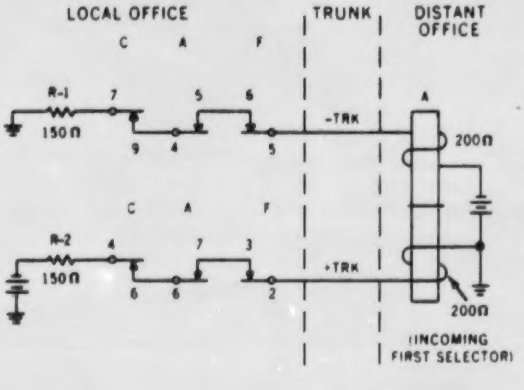

Figure 5-5. Battery pulsing circuit.

opening contact 6 from contact 5 and contact 2 from contact 3.

When the dial pulse springs close during the first pulse, relay A operates again. Relay C remains operated temporarily (it is a slow-releasing relay) while relay A is reoperated. The battery voltage for pulsing is removed from the trunk loop by the contacts of relay A. As the dial pulse springs open and close, relay A restores and operates, connecting the battery pulsing circuit across the loop to the distant office with each operation.

After the last pulse of the last digit dialed has been transmitted, the dial pulse springs remain closed, and relay A remains in the operated position and holds the operating circuit of relay C open. Relay C restores and disconnects the battery pulsing voltage from the loop to the distant office. Relay C also connects the 375-ohm winding of relay D across the loop to the distant office.

Talking circuit. When the called party answers, the current through the trunk from the distant office (through the 375-ohm winding of relay D) develops a magnetic field that aids the magnetic field of the 1400-ohm winding. Therefore, relay D operates. When relay D operates, it reverses current in the line loop of the local office through its make-before-break contacts. The relays of the pulse repeater remain in the positions held, as indicated above, during the period that conversation takes place between the calling and called parties.

Release. The circuit which holds relay A operated is completed through the cradle switch of the telephone of the calling party. The calling party replaces the handset to open the circuit to relay A. Relay A restores and opens contacts 6 and 7, which open the loop circuit to the distant office and the 375-ohm winding of relay D. Contact 2 breaks with contact 3 (opening the holding circuit of relay B) and makes with contact 1. This, however, does not complete the operating circuit of relay C, because relay D has operated and opened its contacts 7 and 8, through which relay C operates.

When relay B restores, it removes ground from the C lead to the outgoing selector in the local office by opening contacts 1 and 2, opens the circuit through the 1400-ohm winding of relay D by opening contacts 3 and 4, opens contacts 7 and 8 through which the circuit to the 375-ohm winding of relay D was completed, and also opens its contacts 5 and 6, which completes a holding circuit for relay C.

When relay D restores, it reverses the flow of current through the loop to the selector in the local office and closes its contacts 7 and 8 to partly complete the circuit to relay C in readiness for the next call.

Relay F restores at the same time as relay D, since its circuit was completed to ground through contacts 3 and 4 of relay B. When relay F restores, it disconnects the pulse repeater from the trunk to the distant office and makes the trunk ready to handle incoming calls by connecting the trunk to the incoming selector in the local office. Relay F also opens the holding circuit of relay E at contacts 8-9.

When relay E restores, it removes ground from, and places negative battery on, the C lead to the outgoing selector in the local office. The pulse repeater is now at normal and ready to handle calls in either direction.

Incoming Calls. Incoming calls reach the local pulse repeater from a similar pulse repeater in the distant office. The pulse repeater in the distant office may or may not be identical with the one in the local office.

Seizure. The pulse repeater in the distant office seizes the incoming selector in the local office over a trunk loop which passes through contacts 1-2 and 4-5 of relay F in the pulse repeater in the local office. When relay B of the incoming selector operates upon seizure of the switch, ground is connected to the C lead. The C lead is in series with the winding of relay E of the local pulse repeater. Ground on the C lead completes the operating circuit of relay E. When relay E operates, it grounds the C lead to mark this pulse repeater busy.

Talking circuit. Relay E of the pulse repeater in the local office is the only relay operated during an incoming call. It remains operated until the switch train is released by the calling party.

Release. When the calling party replaces the handset on the cradle, the switch train is released. When the incoming selector in the local office releases, ground is removed from the C lead, thus opening the operating circuit of relay E. When relay E has restored, the pulse repeater is at normal and again ready to handle calls in either direction.

Exercises (432):

1. What is the purpose of the pulse repeater used in telephone switching centers?

2. In what type of calls are pulse repeaters used?

3. What type of selector is used to receive an incoming call from a distant telephone switching center?

4. Why is the C lead from a step-by-step pulse repeater connected to the bank of a selector?

5. What device serves as the "dialing relay" in a step-by-step pulse repeater circuit?

6. How is a step-by-step pulse repeater identified as being idle?

7. What effect does an operated busy switch have on a step-by-step pulse repeater? (FO 7)

8. What relay operates in the pulse repeater (FO 7), and what causes it to operate on an incoming call?

9. What does the operation of relay E in the pulse repeater circuit (FO 7) do? Why?

433. Using foldout 8's schematic diagram as necessary, indicate those actions that occur in the reverting call switch during typical operation of that switch.

Seizure. When the special second selector cuts through to the reverting call switch, foldout 8, relay A is seized from the line loop.

A relay operates. Contacts 1 and 2 further open a circuit to relay D. Contacts 3 and 4 complete a circuit to relay B.

B relay operates. Contacts 1 and 2 open the circuit that was marking the switch idle with 500-ohm resistance negative battery out on the C lead to the special selector. Contacts 2 and 3 complete a circuit for ground out on the C lead. This ground holds up the preceding equipment and also marks this reverting call switch busy. Contacts 4 and 5 partially prepare a circuit to relay D. Contacts 6 and 7 complete a holding circuit for relay B. Contacts 8 and 9 provide a ground to start the ringing machine if it does not run continuously. The switch has been seized.

Installer Hangs Up Phone. The installer now replaces his handset on the cradle. This opens the line loop and causes relay A to release. These thing follow:

A relay releases. Contacts 1 and 2 complete a circuit to relay D. Contacts 3 and 4 open the operating circuit to relay B, but it does not release for it has a holding circuit.

D relay operates. Contacts 1 and 2 and 4 and 5 open the circuit further to relay A. Contacts 2 and 3 and 5 and 6 complete a circuit for ringing current to flow through the J relay and out the positive side of the line and to return on the negative side of the line. This is referred to as ringing on the positive side of the line. Contacts 7 and 8 complete a circuit to operate relay E.

E relay operates. The E relay is a timing relay. When it operates, it mechanically sets into vibration its weighted spring. Because relay F is slow-to-operate, the intermittent closing of the circuit to relay F does not at first cause relay F to operate. As the vibrations decrease in amplitude, the circuit to relay F is closed for a longer period of time, and shortly before the weighted spring comes to rest, relay F operates.

F relay operates. Contacts 1 and 2 and 4 and 5 remove the ringing current from the positive side of the line. Contacts 2 and 3 and 5 and 6 complete a circuit for ringing current to be sent out the negative side of the line. Contacts 7 and 9 complete a circuit for relay C before the short circuit to relay C is removed by contacts 8 and 9.

C relay operates. The C relay is a timing relay. When it operates, it mechanically sets into vibration its weighted spring. The intermittent short circuiting of the winding of the relay E does not at first cause relay E to restore. As the vibrations decrease in amplitude, the winding of relay E is short circuited for a longer period of time, and shortly before the weighted spring comes to rest, relay E releases.

E relay releases. Contacts 1 and 2 open the circuit to relay F.

F relay releases. Contacts 2 and 3 and 5 and 6 open the ringing circuit from the negative side of the line. Contacts 1 and 2 and 4 and 5 complete a circuit for ringing current out the positive side of the line. Contacts 8 and 9 place a short circuit on relay C, and contacts 7 and 9 open the operating circuit for relay C.

C relay releases. Contacts 1 and 2 remove the short circuit to relay E.

E relay operates. This sequence will continue until the handset is lifted from the cradle.

Installer Lifts the Handset From the Cradle. This completes a circuit for the DC on the ringing circuit to flow through the J relay. These things follow:

J relay operates. Contacts 1 and 2 complete an operating circuit for the H relay.

H relay operates. "X" contacts 1 and 2 complete a holding circuit for the H relay. Contacts 3 and 4 open the circuit to relay D. Contacts 5 and 6 open the holding circuit to relay B, putting it on slow-to-release. Contacts 7 and 8 open the ringing machine circuit.

D relay releases. Contacts 2 and 3 and 5 and 6 open the circuit for the ringing current and the J relay. Contacts 1 and 2 and 4 and 5 complete a circuit to relay A. Contacts 7 and 8 open the circuit to relay E.

J relay releases. Contacts 1 and 2 open the operating circuit to the H relay. The H relay does not release due to a holding circuit.

A relay operates. Contacts 1 and 2 further open the circuit to the D relay. Contacts 3 and 4 complete a circuit to the B relay to keep it from releasing.

Installer Replaces the Handset. The handset is replaced on the cradle. This opens the circuit to the A relay. These actions follow:

A relay releases. Contacts 1 and 2 further open the circuit to the D relay. Contacts 3 and 4 open the circuit to the B relay, putting the B relay on slow-to-release.

B relay releases. Contacts 2 and 3 remove ground from the C lead. This will cause the switch train to release; this also removes the H relay's holding circuit. Contacts 1 and 2 mark the switch idle with 500-ohm resistance negative battery. Contacts 4 and 5 further open the circuit to relay D. Contacts 7 and 6 further open the holding circuit to relay B. Contacts 8 and 9 further open the ringing machine start circuit.

H relay releases. Contacts 1 and 2 open its own holding circuit. Contacts 3 and 4 partially close the circuit to the D relay. Contacts 5 and 6 partially complete the holding circuit to relay. Contacts 7 and 8 partially complete the ringing machine start circuit.

Exercises (433):

1. What happens when seizure of the reverting call switch occurs?

2. When the installer hangs up the first time relay D operates, what do the D relay contacts do?

3. What does the H relay do when the installer lifts the handset of the ringing telephone, and what is the result of the H relay's action?

4. What relays release when the installer hangs up the phone the second time?

434. Using foldout 9 as needed, specify the actions that occur in the switchboard and associated circuits during operation and what affect these operations have on specified equipment as typically employed.

Service failures can be reduced by careful handling of the equipment and by frequent tests and inspections. A thorough knowledge of the functions of the circuit apparatus and an understanding of the circuit operation are necessary to perform efficient troubleshooting and repairs. This section describes the functions of the circuit apparatus used with a typical attendant's switchboard. Circuit schematics and functional diagrams are included (FO 9, figs. 1 through 5) to assist you in understanding the purpose and function of the circuit apparatus and as an aid in troubleshooting.

Universal Cord Circuit. The universal cord circuit used on the attendant's switchboard will interconnect all types of line and trunk circuits, automatically adapting itself to the circuit requirements without any change or adjustment by the attendant. The functions of the circuit apparatus differ with the types of circuits connected at the ends of the cord circuit.

Battery supply to called or calling lines. The universal cord circuit determines, by the sleeve circuit connects, whether the calling telephone and the called telephone are to receive battery supply from the cord circuit. If the cord circuit is connected to a line that requires battery supply, relays in the cord circuit operate, and the call or front supervisory lamp lights. The attendant rings the called telephone, and the calling or front supervisory lamp is extinguished when the called telephone is answered.

Calls to dial lines. On calls which the attendant completes by dialing, the universal cord circuit closes the loop ahead to seize and hold the dial switch train; it lights the calling or front supervisory lamp, permitting the attendant to dial out through the calling (or answering) plug. The calling or front supervisory lamp is extinguished when the called telephone is answered.

Calls on trunks to other offices. On calls which the attendant extends to a distant dial or manual central office, the universal cord circuit closes the loop to the distant office and completes a transmission circuit between the calling telephone and the called telephone.

Splitting. The universal cord circuit is wired to permit the attendant to split the connection—that is, to talk with either the calling or called telephone without being heard at the other telephone. This is done by controls in the operator's position circuit.

Monitoring. The attendant may monitor any call set up with the universal cord circuit.

Adapting the Cord Circuit to the Line Circuit. There are three types of jack sleeve circuits used in the attendant's switchboard equipment. When a plug is inserted into a jack, the jack sleeve controls the operating features of the cord circuit as follows:

Jack sleeve connected to ground. This type of jack sleeve is shown in foldout 9. It is typical of common battery line circuits and trunk circuits from selector levels. When an answer plug is inserted in a common battery line jack, relays B and C of the cord circuit operate. When a call plug is inserted in a common battery line jack, relays E and F operate. In each case, the cord circuit supplies battery to the telephone line. The supervisory lamps are operated by opening or closing the tip and ring of the cord circuit over the loop. When the cord circuit is connected to a calling line, the answer-supervisory lamp does not light if the handset at the calling telephone is off the hookswitch; it does light when the handset is replaced on the hookswitch. The cord circuit call supervisory lamp lights when the cord circuit is connected to the called line, is extinguished when the handset is lifted from the called telephone, and lights when the handset is replaced on the hookswitch.

Jack sleeve connected to ground through a 3,500-ohm resistance. This sleeve type circuit is sheen in foldout 9, figure 3. This type of sleeve is typical of magneto lines, of ring-down trunks—such as some long distance trunks—and of manual office trunks. Relays B and C in the answer end and E and F in the call end of the cord circuit do not operate, and the cord circuit does not supply battery on the line or trunk.

a. Magneto lines. When a plug is inserted into a magneto line jack, no direct current flows in the circuit. Dry cells at the magneto telephone supply battery for its transmitter, and a hand generator or magneto supplies the signaling current. The attendant receives no supervision, and the cord circuit supervisory lamp does not light unless the telephone user operates the magneto; this causes the cord circuit supervisory lamp to light. The supervisory lamp remains lighted until the TALK switch is operated or until the attendant disconnects the plug.

b. Ring-down trunks. The cord circuit closes a direct current circuit over the trunk to serve as a holding bridge to operate and hold the trunk equipment. Supervision on this type of trunk is the same as that on magneto lines.

Jack sleeve open. Foldout 9 also shows this type of jack sleeve circuit. This circuit is used for typical out-dial or one-way-dial trunks. When a call plug is inserted into the out-dial trunk jack, relay D of the cord circuit operates. The cord circuit closes a direct-current circuit over the trunk loop and serves as a holding bridge to operate and hold the dial switch or the trunk equipment. Lifting the handset at the called telephone reverses the connection to the battery supply on the trunk and gives supervisory signals to the operator.

Operation on Common Battery Line Circuit (Direct Ground Sleeve). This is a detailed circuit description of an attendant answering an incoming universal cord circuit, operator's position circuit, as shown in foldout 9, figure 2, and the operator's telephone circuit, as shown in foldout 9, figure 1. A common battery line subscriber demands service by removing the handset and closing a circuit to the B relay in the line circuit.

B relay operates (line circuit). Contacts 4 and 5 close a circuit to the line lamp. The operator inserts the answer plug into the jack. The jack contacts close a circuit to the sleeves of the jack and plug, extending a ground to the windings of relay B and C in series in the cord circuit. The jack contacts also close a circuit to the A relay in the line circuit.

A relay operates (line circuit). Contacts 5 and 6 close a circuit to the busy lamp. Contacts 1, 2, 3, and 4 open the circuit to the B relay.

B relay releases (line circuit). Contacts 4 and 5 open the circuit to the line lamp.

B relay operates (cord circuit). Contacts 1 and 2 close a circuit to the cord supervisory lamp, as foldout 9, figure 2 shows.

C relay operates (cord circuit). Contacts 1 and 2 open the rectifiers. Contacts 4 and 5 close an alternate circuit to the supervisory lamp. Contacts 7, 8, 9, and 10 close the circuit to the A relay.

A relay operates (cord circuit). Contacts 1 and 2 open the circuit to the cord supervisory lamp. Contacts 2 and 3 prepare a circuit for disconnect supervision.

B relay releases (cord circuit). The attendant answers the call by operating the TALK MON key to the TALK position. The bottom set of contacts short the winding of the B relay, which releases but has no function at this time. The third set of key contacts close a circuit to the lower winding of the G relay. The remaining contacts have no functions at this time.

G relay operates (cord circuit). Contacts 3B, 4B, 3T, and 4T extend the voice path from the call side of the repeat coil of the cord circuit to the induction coil (L2) of the operator's telephone circuit. The operator may now talk with the subscriber. Contacts 1B and 2B partially close a circuit to the H relay. Contacts 5B, 7B, 5T, and 7T connect the tip and ring of the call plug to the position circuit. Contacts 1T and 2T complete a locking circuit and an operating circuit for relay A in the operator's position circuit.

A relay operates (opr pos circuit). Contacts 1 and 2 open the original operating path for the G relay in the cord circuit. However, it is locked up. Contacts 3 and 4 further open the circuit to the A relay in the operator's telephone circuit. When the attendant receives the required information from the subscriber, the call can be extended to the called subscriber. Assume that the called subscriber is terminated in the central office on a magneto trunk circuit, which is shown in foldout 9. Then the attendant inserts the call plug into the idle magneto trunk jack. The jack contacts close a circuit to the A relay.

Magneto Trunk Circuit (High Resistance Sleeve). This circuit appears in foldout 9, figure 3. Associated with it are these actions:

A relay operates (mag circuit). Contacts 6 and 7 close a circuit to the busy lamp. Contacts 1 and 2 are used for carrier termination when needed. Contacts 4 and 3 open the circuit to the line or trunk lamp. Contacts 8 and 9 prepare a locking circuit. Relays E and F in the cord circuit will not operate because of the resistors R1 and R2 in series with the ground on the jack sleeve. The effect of these two relays on the circuits is no cord lamp supervision and no transmission battery supplied to the subscriber. The attendant operates the ring key. The contacts of the key accomplish the following: (1) place a ground on the motor start lead to start the ringing generator if it is not running; and (2) open the transmission path through the cord circuit to prevent the calling party from being rung in the ear. The capacitors C5 and C6 bleed off some of the ringing current for ringback tone to the calling subscriber and the attendant. The contacts also (3) connect the generator, positive and negative, to the called line through the call plug. The ringing going through the magneto trunk operates the C relay.

C relay operates (mag circuit). Contacts 1B and 2B short out R1 and close a circuit to the E relay in series with F. The F relay will not operate due to insufficient current. The E relay will not operate, because the 100-ohm winding is shorted by the talk key. The attendant releases the nonlocking ring key; and it returns to normal, removing the ringing current, ringback tone, and opening the motor start leads. Removing the ringing current causes the C relay in the magneto trunk circuit to release. It also partially closes transmission path through the cord circuit.

C relay releases (mag circuit). Contacts 1B and 2B remove the short on resistor R1 and place it in series with the E and F relays in the cord circuit. The attendant restores the talk key, which opens the circuit to the G relay in the cord circuit and A relay in the position circuit. It also opens the short circuit on the winding of the E relay; however, E will not operate because of the high resistance on the sleeve. The call supervisory lamp does not light, but the attendant can monitor to determine whether or not the called telephone has been answered; to do this, the TALK MON key is operated to the MON position. This connects the operator's receiver across the tip and ring of the cord circuit. When the called subscriber answers, there will be no visual supervision, but the operator will hear the called subscriber talking. The monitor key is then restored to normal. The talk key opens the contacts that kept relays B and E shorted in the cord circuit. In this case, relay B will operate in the answer cord circuit, because the cord is connected to a common battery line circuit. When the magneto subscriber disconnects, he must "ring off" by turning the generator crank on the subset. The ringing current operates the C relay in the magneto trunk circuit.

C relay operates (mag circuit). Contacts 1B and 2B short the 2500-ohm resistor, causing relay E in the cord circuit to operate. Contacts 3T and 4T partially close a circuit to the B relay.

E relay operates (cord circuit). Contacts 1 and 2 close a circuit to the call supervisory lamp. When the ringing current is removed, relay C releases, placing the 2500-ohm resistor in series with relay E. Relay E will hold operated until the talk key is operated or the call plug is removed. This will keep the supervisory lamp on until the attendant determines whether or not the lamp is a "disconnect" or "recall." The attendant operates the talk key and challenges the line. The contacts of the key shorts out the winding of the E relay, and it releases.

E relay releases (cord circuit). Contacts 1 and 2 open the circuit to the supervisory lamp. If the magneto subscriber is not on the line, the attendant removes the call plug. The contacts of the jack open the circuit to the A relay.

A relay releases (mag circuit). Contacts 6 and 7 open the circuit to the busy lamp. Contacts 1 and 2 close the idle termination. The remaining contacts are of no consequence at this time. The magneto trunk circuit is now normal. When the attendant operates the talk key to normal, the call portion of the cord circuit is returned to normal. Assuming that the calling subscriber hangs up at this time, the line loop is opened at the subset, and relay A in the cord circuit releases. You will recall that relays A, B, and C were operated when this call was completed.

A relay releases (cord circuit). Contacts 1 and 2 close a circuit to the answer supervision lamp. The attendant removes the answer plug from the jack. The contacts of the jack open the circuit to relays C and B, which release; and the cord circuit is back to normal.

We have completed a call from a common battery trunk to a local battery trunk using the universal cord circuit. The cord circuit furnished transmission battery to the common battery subscriber, but not to the local battery subscriber. You will also recall that the magneto trunk placed a high resistance ground on the sleeve and disabled relays E and F. When some of the resistance was removed, the E relay did operate. The common battery trunk had visual supervision, but the local battery trunk had none. The common battery trunks may be connected, and they will function just as described here, except for the supervision. Local battery trunks may be interconnected; however, there will be no visual supervision until a local battery subscriber rings off.

Selector Level Trunk (Direct Ground Sleeve). This is seen in foldout 9, figure 4. The selector level 0 trunk—shown in foldout 9, figure 4—is a ground sleeve circuit. It is a one-way trunk from the dial telephones to the attendant's cabinet. To access this trunk, any dial subscriber simply dials a "0" into the selector. The selector will select the first available trunk on the tenth level. When the selector cuts through, the subscriber line loop is connected to the tip and ring of the selector level "0" trunk. The calling line loop completes a circuit to relay A.

A relay operates (sel level 0). Contacts 1 and 2 light the line lamp of the face equipment. Contacts 3 and 4 place ground on the motor start lead. Contacts 5 and 6 complete a circuit to the B relay.

B relay operates (sel level 0). Contacts 4 and 5 close a circuit for ringback tone. Contacts 2 and 3 put a ground on the RT (C) lead. When the attendant inserts the plug into the jack, the jack contacts close a circuit to the C relay and the B and C relays in the cord circuit.

C relay operates (sel level 0). Contacts 5 and 6 open the ringback circuit. Contacts 7 and 9 put a ground back on the RT lead to busy this trunk in the selector bank. Contacts 1 and 2 and 3 and 4 disconnect the windings of relay A.

A relay releases (sel level 0). Contacts 3 and 4 open the motor start lead. Contacts 1 and 2 open the lamp lead. Contacts 5 and 6 open the circuit to B relay.

B relay releases (sel level 0). Contacts 4 and 5 further open the path to ringback tone. The remaining contacts have no function at this time. The jack contacts place a ground on the sleeve of the cord through relays B and C in series. The cord circuit will function just as it did on answering a call from a common battery trunk circuit.

We have discussed a grounded sleeve condition and a resistance ground sleeve. There is one more condition to be discussed: an open sleeve or no potential. Some of the circuits that have an open sleeve are: (1) out-dial trunks to line circuits, (2) out-dial trunks to connectors, and (3) two-way pulse repeaters used as a one-way repeater from the switchboard to a distance dial office. Incoming calls are routed into an incoming selector in this case. Notice that all of these circuits are associated with the dial. All of the trunks just mentioned will progress through the switchboard in the same way; that is, the attendant will normally use the call cord to extend a call to the desired jack; then, using the proper keys and dial, dial the digits needed to reach the called telephone. Assume that a common battery subscriber wishes to be connected to a dial subscriber. The attendant usually has two choices of trunks in this case. The first and simplest way is to access the out-dial to connector and dial the last two digits for 100-point equipment or dial the last three digits for 200-point equipment. The second choice is to access an out-dial-to-line circuit, which is the same as a standard line circuit, and dial the whole telephone number. In this text, we will use the out-dial-to-connector trunk to accomplish the stated problem.

Out-Dial to Connector (Open Sleeve). Foldout 9, figure 5, shows this circuit. When the common battery subscriber goes off hook, the attendant answers and receives the needed information. The attendant inserts the call cord into an idle out-dial-to-connector jack which is connected to the correct group of connectors. The jack sleeve is open; therefore, relays E and F in the cord circuit will not operate; however, a DC loop is closed to relay D in the cord circuit and relay A in the connector.

A relay operates (conn circuit). Relay A operates relay B.

B relay operates (conn circuit). Relay B lights the busy lamp on the switchboard. Rectifier A, shown in foldout 9, figure 2, in parallel with the windings of relay D, offers a high resistance to the current flowing from the connector in the normal direction and will cause relay D to operate.

D relay operates (cord circuit). Contacts 2 and 3 light the call cord supervisory lamp. However, if the polarity of the current is reversed, the rectifier offers very little resistance and will conduct most of the current around the windings of relay D. With the talk key operated, relay G operates and switches the tip and ring through the position circuit. G also closes a circuit for relay A in the position circuit. At this time the circuits are in the following condition, as shown in foldout 9, figure 2: relays A, B, C, D, and G in the cord circuit are operated along with the talk key; and relay A in the position circuit is operated. The attendant turns the dial off normal; the shunt springs close a circuit to the B relay.

B relay operates (opr pos circuit). Contacts 1, 2, 3, and 4 open the circuit to the operator's receiver. Contacts 5 and 6 connect C2 and C3 across the tip and ring (T1 and R1). These capacitors are used when calling out on the answer cord. Contacts 7 and 8 close the circuit to the C relay.

C relay operates (opr pos circuit). The C relay is a slow operate relay and is adjusted so that the X contacts make first followed by the Z contacts, which break before the Y contacts make. Contacts 1T, 2T, and 1B, 2B close the dial pulsing circuit. Also, 1B and 2B place the R1 resistor 1000-ohms in parallel with C2 and C3 and the D relay in the cord circuit, preventing the capacitors and relay D from being shorted out by the dial pulse springs. Break contacts 3T, 4T, and 3B, 4B open the R1 and T1 leads to the call plug. Resistor R1 is now holding the circuit to the trunk closed. Relay D in the cord circuit restores. Contact 5T and 6T now close and short R1, leaving the dial connected to the call plug and holding the out-dial trunk.

D relay releases (cord circuit). Contacts 2 and 3 open the circuit to the cord supervisory lamp, and it goes out. The attendant releases the dial, and the pulse springs open, causing the A relay in the connector to release. This steps the connector vertical. The pulse springs reoperate, causing the A relay in the connector to operate, which releases the vertical magnet. This pulsing process continues until the dial returns to normal. This causes the off normal springs to open the circuits to relay C and B. Relay B is slow to release. C will restore first.

C relay releases (opr pos circuit). Contacts 5T and 6T open the short on the R1 resistor. Contacts 3T, 4T, and 3B, 4B connect the out-dial trunk to capacitors C2, C3, and relay D in the cord circuit. Contacts 1T, 2T, and 1B, 2B open the circuit from the dial and resistor R1 to the out-dial trunk.

D relay operates (cord circuit). This lights the cord circuit supervisory lamp.

B relay releases (opr pos circuit). Contacts 5 and 6 open the C2 and C3 capacitors. Contacts 1, 2, 3, and 4 connect the operator's telephone circuit across the cord circuit. This operation is repeated for each digit dialed into the connector. When the last digit has been dialed, the connector completes the circuit to the called line and rings the telephone. The attendant restores the talk key to normal. The contacts of the key open the circuit to the G and A relays.

G relay releases (cord circuit). The G relay disconnects the operator's telephone and position circuit and connects the call cord to the calling cord. The call cord supervisory lamp is lighted; and when the subscriber answers, the D relay in the connector reverses the current to the D relay in the cord circuit. The A rectifier offers low resistance to the reverse current and shorts the D relay out.

D relay releases (cord circuit). This extinguishes the call supervisory lamp. The two subscribers may now converse.

Dialing Over the Answer Cord. Another use of the cord circuit is to dial out on the answer cord. The situation could be such that a manual subscriber on a common battery trunk is connected to the call cord and wishes to make another call. The subscriber operates the hookswitch, flashing the supervisory lamp, which the operator answers by operating the talk switch. The operator may extend the call by using the answer cord. The attendant plugs the answer cord into an out-dial-to-connector jack and must then dial over the answer cord to signal the originating subscriber. When the attendant inserts the answer plug, a circuit is closed to the A relay. Relays B and C do not operate because of the open jack sleeve.

A relay operates (cord circuit). A relay turns on the answer cord supervisory lamp. Rectifier A is reversed bias and will not conduct. The dial ANS key in the operator's position is operated and closes a path for D relay.

D relay operates (opr pos circuit). Contacts 3B and 4B place a ground on the H lead and prepare a path for the F relay. Contacts 1T and 2T open the ground for the A relay in the operator's position circuit and the G relay in the cord circuit. G is a slow-to-operate relay; thus, it will be a little slow to release. Contacts 5B, 6B, 6T, and 4T connect the operator's telephone circuit and the position circuit to T3 and R3. Contacts 2T and 3T complete a path to the H relay.

H relay operates (cord circuit). 1T and 2T close a holding path to itself. Contacts 3T, 4T and 5T and 1B, 2B and 3B transfer the out-dial trunk circuit from the A relay to the retard coil L1 in the position circuit.

A relay releases (cord circuit). Contacts 2 and 3 extinguish the answer supervisory cord lamp.

G relay releases (cord circuit). This connects the call cord to the repeating coil and disconnects the operator's position circuit from the cord circuit. The attendant dials the original calling subscriber; the dial is connected to the answer cord. When the last digit is dialed, the connector sends out ringing current. The attendant restores the dial answer key to normal, and the contacts open the circuit to relay D in the position circuit.

D relay releases (opr pos circuit). Contacts 6T and 5T connect R5 across the T3 and R3 leads to hold the loop operated until H relay releases. Contacts 4T, 6T, 1B and 2B open the dial pulse leads. Contacts 4B and 3B open the holding circuit to H. Contacts 1T and 2T close the circuit to the G relay in the cord circuit.

H relay releases (cord circuit). Contacts 2B, 3B, 5T, and 4T connect the repeat coil and relay A to the trunk, while contacts 3T, 5T, 1B, and 3B open the circuit to R5, which is no longer needed.

A relay operates (cord circuit). The contacts light the answer supervision lamp.

G relay operates (cord circuit). Relay G locks in series with relay A in the position circuit. Relay G extends the call side of the repeating coil to leads T1 and R1, also T and R of the operator's circuit.

A relay operates (opr pos circuit). Contacts 1 and 2 open the original operating path to relay G. Contacts 3 and 4 open the monitor circuit. The operator may either remain on the connection until both subscribers are on the line or withdraw to take care of other calls. Restoring the talk key will release the G relay in the cord circuit and relay A in the position circuit.

G relay releases (cord circuit). This transfers the talking circuit from the operator's circuit to the call cord. When the calling subscriber answers, the connection reverses the direction of current flow through the trunk. Rectifier B is forward biased and will conduct, short-circuiting the winding of A relay, which releases.

A relay releases (cord circuit). Relay A opens the circuit to the answer supervisory lamp. When the subscribers disconnect, the connector reverses the direction of current flow through the rectifiers. This causes the A or D to operate, completing circuits to the cord supervisory lamps. The attendant then removes the plugs from the jacks, and the circuits are back to normal.

Exercises (434):

1. What determines whether the calling telephone is to receive transmission battery from the cord circuit?

2. What do the contacts of the B relay in the common battery circuit (FO 9, fig. 1) do when relay B operates?

3. When does the A relay in the common battery line circuit (FO 9, fig. 1) operate?

4. How does the switchboard operator know whether a given connector is idle?

5. What do the contacts of an operated A relay in the trunk circuit from selector level 0 (FO 9, fig. 4) do?

6. Will the switchboard cord circuit provide transmission battery to subscriber's calling in on the 0-level trunk? Why?

7. What is the path from the tip of the answer cord, through the impulse springs of the dial, and then to the ring of the answer cord when the DIAL ANS key and the TALK keys are operated and the dial is off normal (FO 9, fig. 2)?

8. In what order must the TALK key for a cord circuit and the DIAL ANS key be operated, in order to dial over the answer cord? Why? (FO 9, fig. 2)

5-4. Troubleshooting the Attendant's Cabinet and Miscellaneous Trunk and Switching Equipment

At this point in your study of the Strowger switching system, you are aware of the principles involved in circuit operations, both relay and switching.

You are also aware that a knowledge of circuit functions, the ability to read and interpret schematic diagrams, and the ability to use a systematic troubleshooting approach are the prerequisites to finding and fixing troubles in your central office.

435. Using foldouts 6, 8, and 9, as needed, determine the probable causes of trouble and state the necessary actions in each situation.

In this chapter, we have discussed the functions and circuit actions of the attendant's cabinet, some of its associated circuits, and several miscellaneous trunk and switching equipment circuits. You have been working with a proven troubleshooting approach for the last five chapters; so without further discussion, let's take up some trouble symptoms. Should you encounter any difficulties, refer again to the previous sections of this chapter that deal with circuit operation. This should not need saying, but nevertheless, we will say it again—get the schematics (FOs 6-9) out and use them.

Exercises (435):

Use the foldouts indicated to determine the cause of trouble and, when indicated, the corrective action for the following trouble symptoms:

1. When using the answer cord 14, there is noise on the line. Dirty relay contacts are suspected as causing the noise. What contacts would most probably be causing this noise? (FO 9)

2. The operator cannot dial on any of the answer cords on switchboard position 1. What relay has failed to operate; why didn't it operate; and what is the corrective action? (FO 9)

3. If A relay contacts 1 and 2 in common battery line circuit (FO 9, fig. 1), are dirty, what type of call is affected?

4. When the selector attempts to switch through to the first selector level 0 trunk (FO 9, fig. 4) in its banks, the A and B relays of the trunk circuit operate; then the selector releases; what is the trouble?

5. After seizing the reverting call switch, the installer hangs up. When the phone fails to ring, the installer again picks up the handset and hears the dial tone. What is the most probable reason and cause? (FO 8)

6. The operator pushes the FIRE button to extend a call to the fire department; but nothing happens. What is the most probable cause? (FO 6)

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CHAPTER 6

Central Office Maintenance

IN THE PREVIOUS volume and the five chapters of this volume, you have studied about relays, stepping switches, troubleshooting, circuitry, PMIs, cabling, etc. Now you are probably wondering, "What can be left?" Well, not much; but what is left is very essential—a couple of pieces of test equipment for PMIs and troubleshooting, call tracing, switch tags, bay cards, and DTA.

All of this does not sound very impressive, but when you think about it, it's mighty important in your day-to-day activities in the central office.

6-1. PMIs and Test Equipment for Troubleshooting

In Volume 2 we discussed the types of PMIs, the purpose of PMIs, and the use of the workcard type tech orders. Now it is time for us to look at some PMIs that are performed in Strowger exchanges and the test equipment used.

436. Using figures 6-1 through 6-4 and representative descriptions of malfunctioning equipment operation, state the type of PMI and test equipment to be used to localize each problem and why the approach adopted should be used.

Stepping-Switch Test Set. Some repairmen identify this unit as a varying machine. You carry this set by means of a handle at the top of the case.

Components. The unit consists of an electric motor, a reduction gear box, an interrupter assembly, a relay, wire-wound resistors, and rotary switches. Associated with the test box and often considered to be a part of it are the extension switch box, test plug, extension cord, and battery cord. With this test set, a repairman makes periodic tests of the vertical stepping of selectors, vertical and rotary stepping of connectors, and tests of the operation of incoming selectors and trunking repeaters. Figure 6-1 illustrates the battery cord, extension cord and test cord connections at a switch shelf and at a stepping-switch test set. Note, also, that the battery cord is connected to the fuse panel with spring clips. The extension switch box has three pushbutton switches for operating the devices in the test box. Depression of the loop switch connects 1000 ohms into the pulsing circuit of the test set. Depression of the RLS switch disconnects the test set from the equipment under test. Depression of the shunt switch connects additional resistance to the test circuit of the test set.

Functions. This test set permits a test of telephone system equipment by providing impulses to the pulsing relay. From this test set, machine impulses rather than dial pulses are provided to the operating winding of the pulsing relay. Figure 6-1 shows the connections between the test set and the test jacks on the equipment shelf. By inserting the battery cord plug into the BAT jack of the test set, you operate the test set motor. Depression of the loop switch connects 1000 ohms and the motor impulses to the test jack of the equipment. Figure 6-2 illustrates the loop circuit to a pulsing relay. In turn, nine pulses affect the pulsing relay. You should observe the equipment and determine whether or not the unit is operating satisfactorily under these conditions. Remember: Too much resistance in the circuit causes the pulsing relay to operate slowly and release too soon—as a result, the operating sequence of the devices that follow its operation will be changed or broken. Consequently, a connection will not be possible.

Operation of the shunt switch makes a similar test of the pulsing relay, except that the switch contacts connect the relay winding to 15,000 ohms of resistance. Your operation of the release switch permits the equipment under test to restore.

Performance Routine of Selectors. Since several test devices exist for routining selectors, we realize that there are variations in the testing methods. For the most part, though, the procedure principles used with each are essentially the same.

Routining with a test telephone handset. After having inserted the plug into the selector test jack, you normally listen for a dial tone. The reception of dial tone assures you that the seizure relay has operated. Following the tone reception, dial the digit for the selector level which you desire to test. Dial tone should cease. Also, you should be able to see relays operate and, in some equipment, lamps operate. (The lamps may be on test equipment or on the switching

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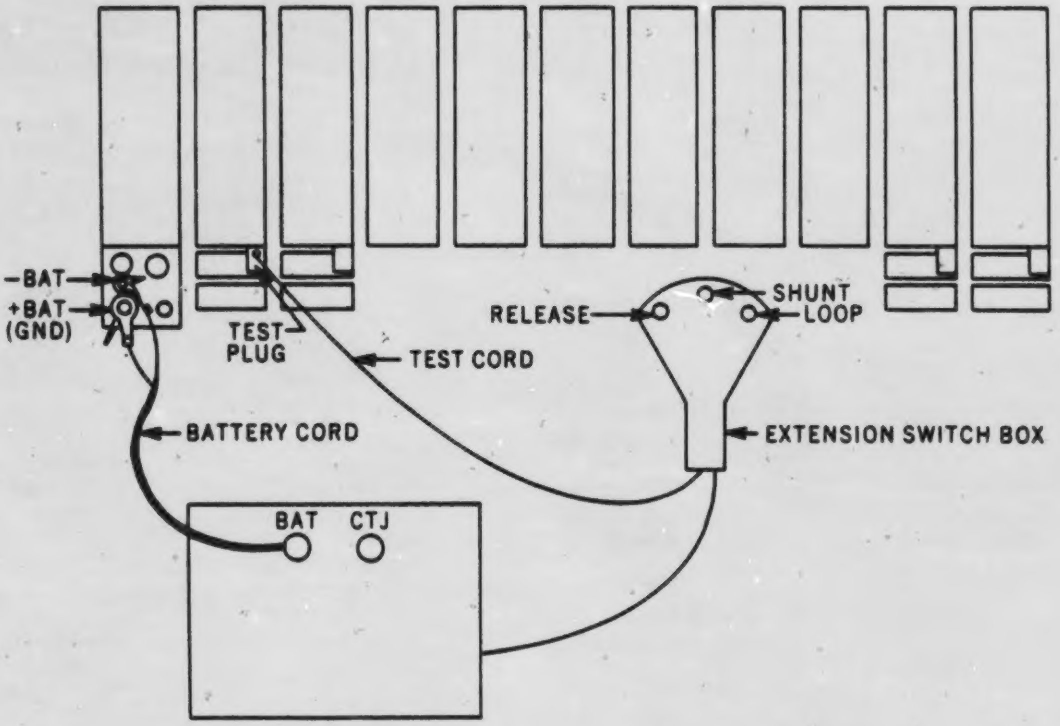


Figure 6-1. Stepping-switch test set, cording diagram.

equipment.) If access to the following equipment is not possible, a busy tone will be heard in the test telephone. By operating the releasing switch, you restore the relays. Continue operating and releasing the handset switches as you dial and, at the same time, observe equipment to see whether or not all trunks and equipment for that selector have been tested.

Repeat the selector testing by plugging the test set into the test jack of other selectors, dialing the proper numbers, and observing for equipment operation. Second selectors are tested in a like manner, except that you dial the test numbers of the connector groups.

Routining with a stepping-switch test set. The testing procedure for selectors while using this device differs from the test telephone handset in that nine pulses are applied to the equipment when the loop switch is depressed. Since this testing device is primarily used at a step-by-step switching center, the procedure that we are describing is applicable to Strowger selectors. The selector steps to the ninth level, where rotary motion occurs. If all trunks are busy or if the ninth level is vacant, the selector will step to the eleventh position. Consequently, the equipment returns a busy tone. An idle trunk in the ninth level will cause the switch to stop stepping. You should then momentarily operate the vertical off-normal switch lever, located at the top of the switch frame, and notice whether or not the selector advances to the next trunk. Failure to advance indicates an open trunk.

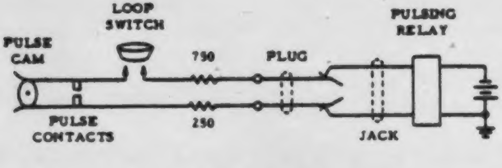


Figure 6-2. Loop circuit from test set to pulsing relay.

Test each trunk in this manner. If no trunks are busy, operate the busy switches and observe the selectors again. Each selector should step beyond a busy trunk.

Type 26A Switch Tester. This test set is designed to test the functions of the local, full toll, and reverting call connectors, toll selectors, reverting call switch, and pay station repeaters. Brief descriptions of the controls, cords, lamps, jacks, and the various tests follow:

a. The remote control set enables the testman to perform a connector inspection within 16 feet of the test set. It has a dial and keys corresponding to those on the test set.

b. The remote control cord is plugged into the remote control jack, figure 6-3, which is a 15-conductor receptacle.

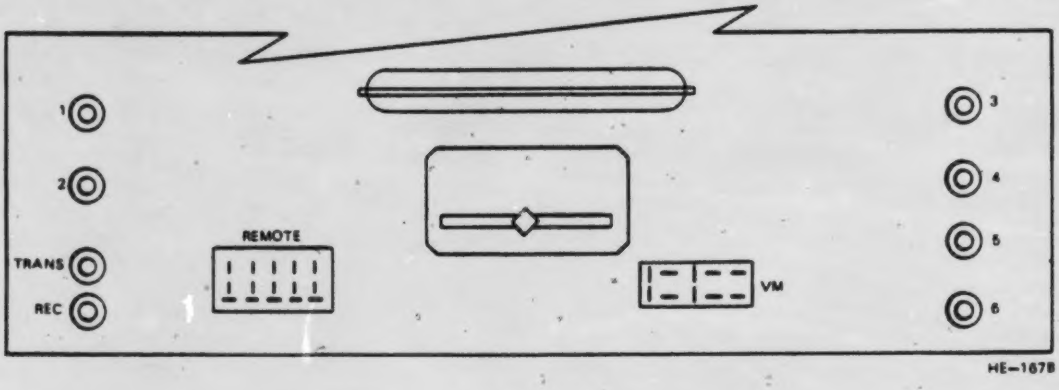


Figure 6-3. Type 26A switch tester jack and receptacle panel.

The testman uses the headset to monitor the tones returned from the switch.

c. The calling cord connects the individual connector switch test jack (–, +, and C-lead) to the CALL jacks 1 and 2 of the switch tester.

d. The answer and 48V cord connects the shelf test jacks (battery and ground and –, +, and C-leads) to ANS jack 3 and 48V jack 4 of the switch tester. See figure 6-4 for the rest of the indicators and controls.

e. The buz switch (ON/OFF) causes the buzzer to operate in parallel with C-BAT RING lamp (white) when a connector sends ringing current to the test line.

f. The START turn key completes a loop in the tester to seize the switch.

g. The FALSE TRIP key checks the adjustment of the ring trip relay (L) of the connector. The ANS key checks the ring trip (L) relay and the back relay (D).

h. The RLS key opens the loop releasing the switch under test. The BUSY key places ground on C-lead bank contact of the test terminal to mark the test line busy.

i. The LK key places a 15,000 ohm shunt (parallel) resistance across the pulsing loop to simulate a leak on the line.

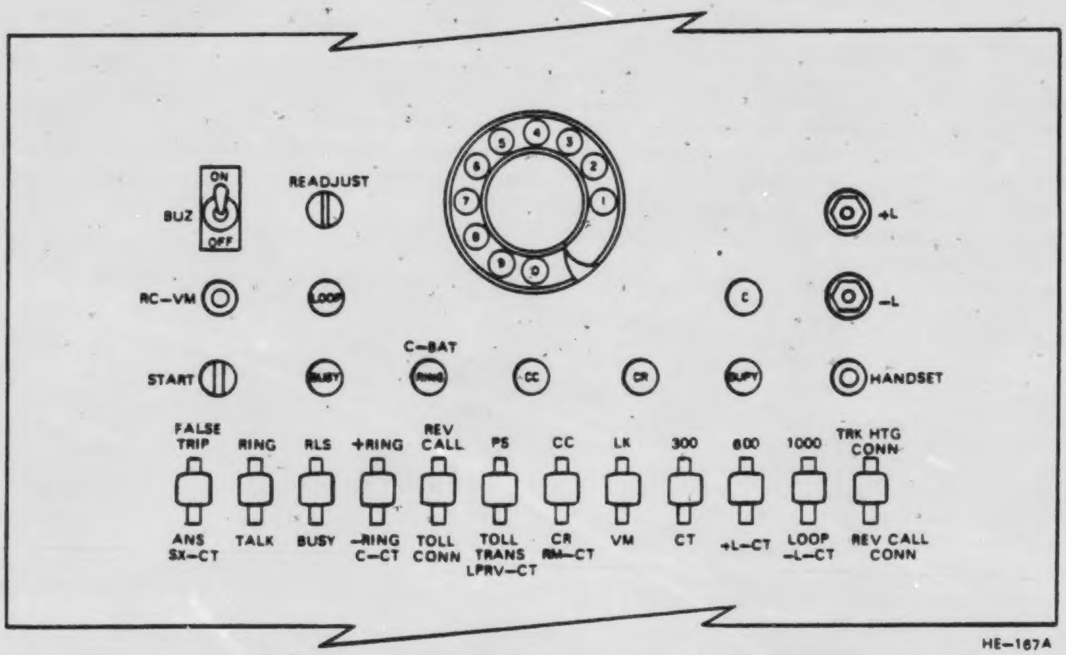


Figure 6-4. Type 26A switch tester control and indicator panel.

j. The 300, 600, and 1000 keys, respectively, simulate a line condition by placing a balanced resistance in series with the pulsing loop. Keys are used singularly or in combination.

k. The READJUST TURN key provides for adjusting ring-trip relay under operating conditions.

l. The BUSY (red) lamp indicates the condition of the switch before seizure. When the test set is first connected to the switch jacks, the lamp lights if the switch is busy.

m. The LOOP (white) lamp indicates that a loop in the tester is complete to the switch under test.

n. The C (green) lamp provides C-lead supervision.

o. The C BAT RING (white) lamp indicates supervision while ringing current is applied to the test line.

p. The SUPY (white) lamp furnishes loop supervision.

q. The TRANS AND REC jacks provide for connection of the operator's headset.

r. Jacks 1 and 2 provide a connection for the test set to the switch test jack.

s. Jacks 3 and 4 provide a connection for the test line, 48V battery, and ground.

t. The HANDSET jack provides for connection of the hand test telephone which may be used in place of an operator's headset.

u. The REMOTE jack is a receptacle for interconnection between the tester and remote control set.

Testing With the Type 26A Switch Tester. The Loop and Leak Pulsing Tests, False Trip and Trip Tests, and Readjusting False Trip Relay are explained next.

The *Loop Pulsing Test* performed with the tester is to test the dial pulsing under different amounts of resistance—300, 600, 1000 ohms. The resistance keys may be operated separately or in combination to provide the proper series loop resistance. Dial the test number 199 (299) and check operation of switch. This test may be accomplished after switch seizure when performing the connector inspection.

The *Leak Pulsing Test* is to test the pulsing of the switch under a leak condition. The operation of key LK/VM to the LK position puts a 15,000 ohm shunt across the pulsing loop which removes all loop resistance. Dial the test number 199 (299). If the switch does not step properly, it is considered faulty. This test may be accomplished when the ring test is performed in the connector inspection.

The False Trip and Trip Tests are performed during the silent period of the ringing cycle.

The *False Trip Test* is performed when the RING lamps goes dark and the buzzer stops on the silent period. Operate for one-half second the FALSE TRIP/ANS key to the FALSE TRIP position. The key must be restored before the next cycle of ring.

Operation of the FALSE TRIP key operates a relay which places 2300 ohms across the − and + leads. The ring trip relay (L) should not operate on the dc flowing at that time. If the ring trip relay operates, it requires readjustment. At the beginning of the next ringing cycle, the RING lamp lights and the buzzer sounds.

The *Trip Test* is performed during the next silent period of the ringing cycle. The FALSE TRIP/ANS key is operated for one-half second to the ANS position. This places 1600 ohms across the − and + leads. The trip relay (L) should operate on the dc flowing through the resistance.

If it does not operate, the adjustment of the trip relay is too stiff and needs readjusting. The RING lamp lights and the buzzer sounds on the next ringing cycle.

If the L relay did not pass either the False Trip or Trip Test, repeat the applicable test with the READJ key operated. The READJ key lowers the resistance to 2100 ohms and raises the trip resistance to 1800 ohms.

The preliminary armature springs (X) of the ring trip relay should have tension increased or decreased as necessary to meet the false trip and trip tests.

Test Handset. The test handset, while not a sophisticated piece of test equipment and limited in its electrical configuration so far as circuit conditions go, is probably the most versatile piece of test equipment in your exchange.

With the test handset, you can perform operational tests in almost all of the equipment in the office. It is quicker and easier to use than most other test equipment that you perform PMIs with, and, for all practical purposes, almost as good.

We are not advocating that you throw out your automatic equipment routiner and varying machine. We just want you to use the best piece of test equipment for the trouble you've got to work on.

Exercise (436):

1. Which piece of test equipment, a test handset or a varying machine, should be used *initially* to test a selector switch reported to be stepping erratically in the vertical direction? Why?

2. What is the advantage of the varying machine over the test handset?

3. When is the false trip test performed using the type 26A switch tester?

4. What does operating the FALSE TRIP key on the type 26A switch tester do in the circuit of the connector under test?

6-2. Uses of Call Tracing

Call tracing has, over the years, been glamorized in movies and on TV. You have seen where tracing a call has saved someone's life, helped catch the bad guy, etc. The truth of the matter is, call tracing is done more often for maintenance and troubleshooting than for any other reason.

To trace a call requires certain items to guide you through the exchange—sort of like a road map. These guides are switch tags, bay cards, and the DTA drawing. We will next look at each in turn, at how they work together, and at the procedure for tracing calls. One other necessity is knowing how the switching equipment is connected within the exchange.

437. Using figures 6-5 and 6-6 and selected necessary information about switch tags, insert that information into the correct section and interpret the relevant bay card and DTA drawing information briefly and accurately. Consult foldout 10 as required.

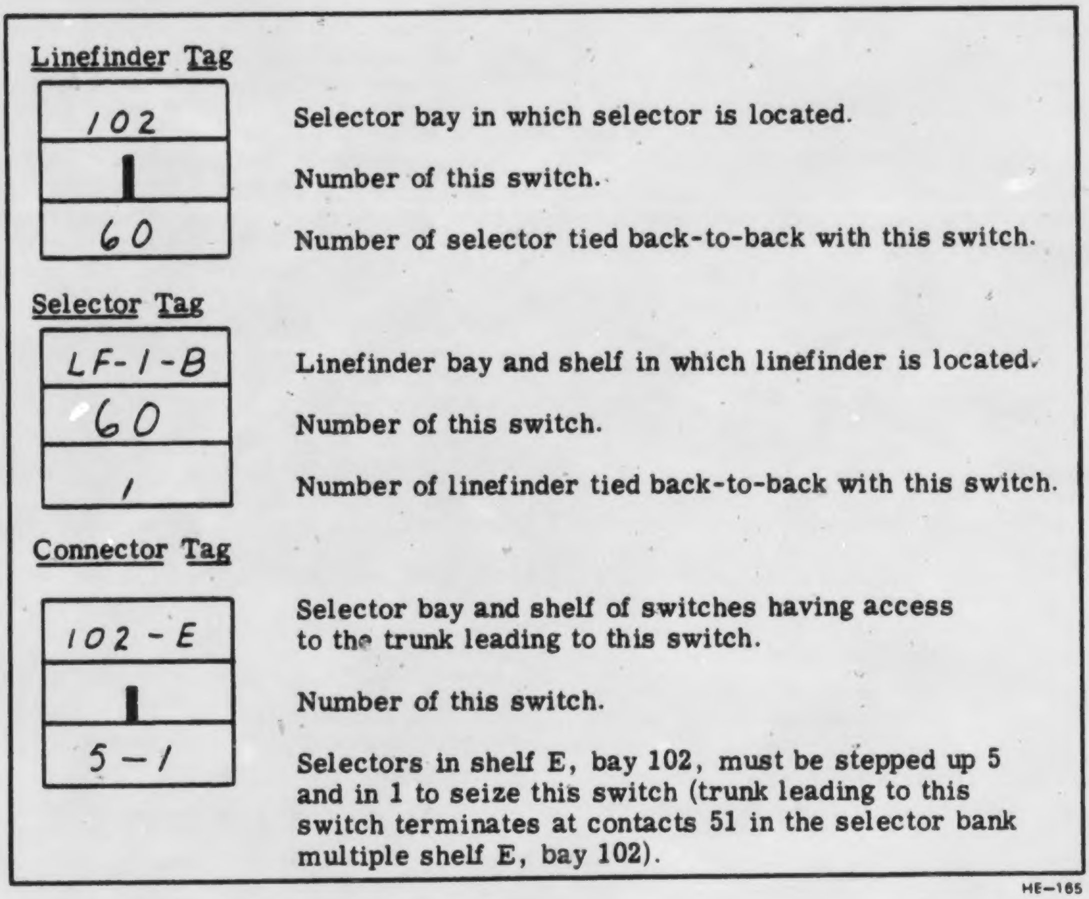
Let us quickly review the connections between various pieces of central office equipment. A linefinder is connected back-to-back with a specific first selector. All of the other pieces of switching and trunking equipment are connected from the banks of selectors (first, second, special second) to the back of the succeeding equipment.

Trunks that terminate to the back of (directly to the circuit) second selectors, special second selectors operator's trunks, city trunks, and AUTOVON trunks are also terminated, through the DTA, to the banks of the first selectors.

Trunks terminated at the banks of special second selectors, again through a DTA, are information, fire, reverting call, test desk, and dial speed.

From the banks of the second selectors extend trunks to third selectors (depending on the size of the exchange) or connectors.

Switch Tags. Each switch in the central office has a tag which provides information for use in tracing calls to or from a switch. The tag is ruled into three equal



Selector bay in which selector is located.

Number of this switch.

Number of selector tied back-to-back with this switch.

Linefinder bay and shelf in which linefinder is located.

Number of this switch.

Number of linefinder tied back-to-back with this switch.

Selector bay and shelf of switches having access to the trunk leading to this switch.

Number of this switch.

Selectors in shelf E, bay 102, must be stepped up 5 and in 1 to seize this switch (trunk leading to this switch terminates at contacts 51 in the selector bank multiple shelf E, bay 102).

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Figure 6-5. Typical switch tags.

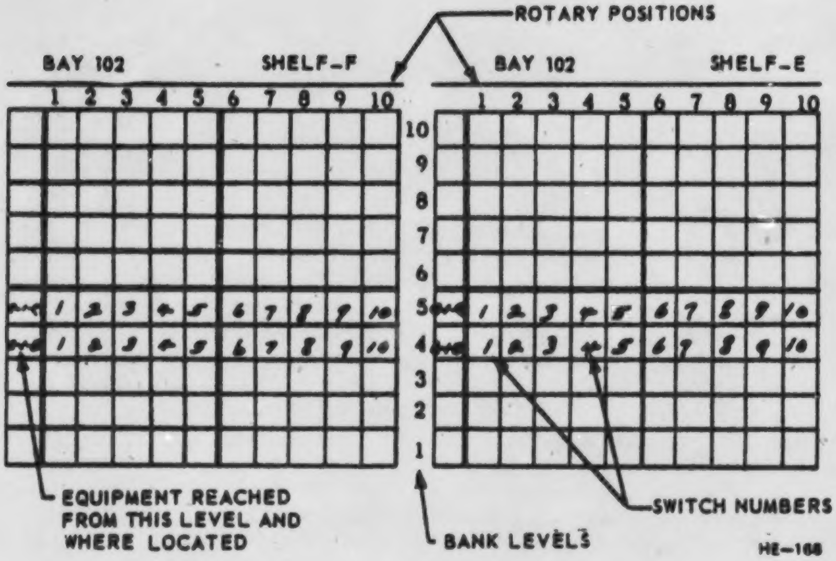

Figure 6-6. Typical bay card.

sections by two horizontal lines, as shown in figure 6-5. A number which corresponds to the position of the switch in the shelf or bay is printed in the center of the tag. That is the switch number. The other two sections of the tag contain information which indicates what is connected to the jacks of that switch.

NOTE: The pulsing and/or talking circuits of a switch train go through the jacks, a set of line bank contacts, and the wipers.

Study figure 6-5 until you can accurately give whatever exact information about the linefinder, the selector, and the connector tags you may be asked.

After your study of figure 6-5, you should know that the linefinder switch tag tells you what switch is next in line. The first selector switch tag tells you where you "came from" and is a good way to cross-check your progress when call tracing. But, the connector's switch tag is somewhat different. It is, like the selector switch tag, used for tracing back to the preceding equipment. It also contains the selector shelf and bay (one of them) and wiper position—of the selectors in that shelf—to which it is connected. Switch tags for second, third, and special second selectors are similar to that for the connector.

You probably wonder what happened to the DTA in the above discussion. It has not been forgotten and will be taken up later in this chapter. First, though, let's look at the bay card.

Bay Card. Each pair of adjoining selector shelves requires one selector bank designation card. The card is divided into two sections—one section for each of the shelves in that row of selector across the bay, as shown in figure 6-6.

The purpose of the card is to indicate *what* each selector in that particular shelf has *access to* on each of its 10 bank levels. To the left of each row (level), a space is provided to record and indicate what type of equipment is cross-connected to that bank level on the selector. This space also indicates where the equipment is located.

Each row is further divided into 10 blocks, which represent the bank contacts. The number in each block indicates the number of the switch which is reached from that set of bank contacts.

The levels are numbered from 1 through 10 in the space *between* the two sections of the card. Rotary positions are numbered from 1 through 10 *at the top* of each section of the card.

Space is provided at the top of the card to indicate the shelf letters and the bay number.

Let's say that a selector on shelf F, bay 102, is stepped up 4 and rotary 5. We want to know where this particular card connection is extended. Look at the first section of figure 6-6. Count up 4 and rotary 5; the number in the little square is the number of the next switch. To locate this switch look to the extreme left of this level, and you will see *C-1-B*. This tells us that the call is extended to switch 5 in connector bay 1, shelf B.

Distributing Terminal Assembly (DTA). Represented on the DTA drawing, foldout 10, are these three major component areas:

- Bay 101 and bay 102 and their shelf assemblies.
- The distributing terminal assembly (group of points), found in the center of foldout 10.
- On the far left and right sides of the drawing, vertically drawn forms for reading data on tie cables,

double jumpers and jumpers between tie cables, and outgoing trunk (OGT) terminal blocks are shown.

To the left and right of the drawing (FO 10), under bay designation, the symbols A, B, C, etc., designate the shelves. G, H, J, K, and L are the only ones occupied in bay 101. The type of circuit, such as "Local 1st Selector," is shown above the top of each group of circuits. Under the shelf symbol, the mounted switches are shown. Look at bay 101, shelf G, switches 61 through 70. Do you remember how selectors are numbered? The run number of the incoming cable is shown encircled above the shelf symbol.

The selector-bank-level distributing terminal strip portion of the drawing represents the bank terminal punchings for each selector shelf level by 10 vertical columns of points (dots). Each level is numbered across the top of the drawing. Each row represents 10 sets of contacts from 1 level of 10 selector banks in one shelf of selector. Each single point represents three terminals, tip (+), ring (−), and control (C). An unequipped extra row is furnished at the top of the drawing for showing tie cable terminations. A tie cable is a cable between two distributing frames or distributing points.

On foldout 10, bay 101, shelf A, look at the third dashed line below the shelf designation. With your pencil follow the line to the row of points which represents the bank levels 1 through 10. Do the same for shelf B; it lines up with the third row of points. Now go to bay 102 and do the same thing with shelves A and B. Level 1 for these shelves will be across the drawing to the left. Notice how every two shelves in bay 101 and bay 102 alternate. The DTA serves as a termination point for the selector banks. The banks are now spread out, so jumpers may be connected to the next component.

Outgoing trunk (OGT) terminal blocks are represented by two sets of vertical lines to the left and right of the selector-shelf bank assemblies. The lines are divided as required to show the mountings for 24 terminal blocks. Each row of blocks is shown in two lines, each line representing one-half of the full strip. One line represents "Top to Center," the other, "Center to Bottom." The ends marked "Center" on each line join on the actual strip. Look at foldout 10; the terminal blocks in use are marked with a heavy dark line. The designation numbers of cable runs, frames, and levels are shown along the vertical line representing the terminal block.

Multiple Arrangements. Selector shelves have a capacity of 10 switches. The banks of each 10 switches are multiplied together. Each set of 10 banks is wired to a distributing assembly, where it is possible to further multiple together, level by level, as many sets of banks as may be desired in order to provide the selector loads for the outgoing trunk groups from the selector levels. The shelves levels are multiplied together by the straps on the front of the DTA. There are two general types of multiples; straight and graded.

Straight multiple. Since each level of a selector bank contains 10 contacts, each set of 10 selector banks may be provided with a maximum of 10 trunks per level. Two or more shelves may be multiplied to share 10 trunks. This is known as "straight multiple," and results in a group of 20, 30, 40, etc., selectors hunting over a common group of 10 trunks—levels 1, 9, and 0.

Look at level 2 on foldout 10. Shelves F, E, and G in bay 102 and shelves G and H in bay 101 are sharing trunks 11, 12, and 13. These trunks are called common trunks. The vertical line represents the straps on the front of the DTA, connecting the 5 shelves (50 switches) to the 3 outgoing trunks. This is also a straight multiple.

The points 4 through 10 on this level have a horizontal strap which is connected to ground. This shows that these points have no trunks connected to them. The ground potential makes it possible for the selector switch to step rotary and return all trunks busy tone when the wipers hit the fourth rotary step on the second level.

Check levels 6, 7, and 8 on the DTA drawing and note that they have the same straight multiple as that used on level 2.

Graded multiple. When the theoretical number of trunks required to carry the traffic from a level exceeds 10, the graded multiple is employed. Refer to level 5 on foldout 10.

Grading is a method of associating a number of selector banks together in the distributing terminal assembly, so that in the trunks from the levels, each group has access to individual outgoing trunks in the early choices but, on later choices, shares access to trunks with other groups. The essential characteristics of a graded multiple are that the trunks "hunted" over *first* serve a minimum number of switches; the trunks "hunted" over *last* are multipled over more of all of the switches.

Look at shelf E, bay 102, level 4; trunks 221, 226, and 230 are used by the 10 switches in this shelf. Trunk 233 is shared by shelves E and F (20 switches). Check shelf G, bay 102; it has only one trunk 225 for its exclusive use. Trunks 299 and 232 are common to two shelves. Find trunk 240; it is common to 5 shelves (50 switches).

Common trunks—those which are connected to all selector banks in the graded group—may be reversed to provide alternate choice of trunks to distribute the use of the trunks. These reversals are installed midway between the selector banks; see level 4. In *common trunk groups* the reversal is installed between the first and the next-to-the-last trunk. Trunks 235 through 239 are common to five shelves. Use your pencil and trace the path for 235 and 239. All of the points between the two trunks are reversed strapped on the actual DTA. Remember that the reverse symbol indicates that everything in between is strapped. Trunk 240, the last, is connected straight down the DTA to facilitate the use of last-trunk-busy meters which may be connected to the last trunk in the group.

Assignment of Outgoing Trunk Numbers. Careful assignment of outgoing trunk (OGT) numbering is necessary to produce an even distribution of traffic over succeeding shelves of switches. The trunk numbers shown on the DTA terminal punchings should correspond to those shown on the vertical terminal blocks at either end of the frame to which they are connected. The choice of a trunk numbering pattern is governed by the number of trunks connected to each level and the type of succeeding equipment to which these trunks are connected.

A straight multiple. Where 10 or less trunks are connected to any selector level, the trunks are connected, in order, to the top row of punchings, with the lowest number at the left. The multiple strapping for circuits 1 to 9 is reversed between the two selector shelves nearest the middle of the equipped shelves. The tenth circuit, which may be used for connection to intercept trunks or all-trunks-busy registers, is carried straight through all selector shelves without a reverse. Levels 1, 9, and 0 on foldout 10 are examples of the trunk assignments on a straight multiple.

On a graded multiple. Where more than 10 trunks are connected to any 1 level, a graded multiple is used, so that the traffic over each trunk group to succeeding equipment may be evenly distributed. The pattern used for trunks from selector levels to connector bays is in a straight numerical sequence. Look at level 4 on foldout 10. Start with the lowest numbered trunk and follow the numbers in sequence. The numbers are assigned to the strapping pattern from the top down and from left to right, in order.

Since there are 20 trunks (221-240) on level 4, check their termination on the terminal block; look to the left at the symbol for the GT terminal blocks. Find the trunk count 221 through 240. The bracket shows that these trunks are in cable run 26A. It also tells you that the trunks are going to connector bay 1, shelf B, and to the numbers 4100-4200. Check all of the trunk numbers on the rest of the levels and determine where they are going.

It is important to remember that the trunk assigned to the next piece of equipment (switch/lamp) is numerically assigned. The first trunk is assigned to the first succeeding switch on the shelf, etc., until all of the trunks have been terminated at their respective switches. In foldout 10, trunks 361-370 are terminated at the special selectors, shelf H, switches 71-80. Trunk 361 is terminated at switch 71; 362, at switch 72, etc. Look at the trunks on the fourth level. You have 20 trunks, 221-240, going to the 20 connectors on shelf B in the connector bay (see OGT block on foldout 10). Trunk 221 is terminated at connector 1 on shelf B in connector bay 1. Look at levels 2, 6, and 7. All of the trunks on these levels are going to shelf L (A-A Rep). Notice that trunks 11, 12, and 13 go to repeaters 111, 112, and 113. Trunks 14 and 15 go to repeaters 114, 115. Check the rest of the trunks and determine the switch numbers at which they are terminated.

Vacant levels. Look at bay 102, shelf H, and levels 1, 2, 4, 5, 6, 7, and 0. These levels are not used (vacant) by the special second selectors; so the levels are horizontally strapped to ground. If any special second selector is stepped to these levels, it will then step to the eleventh rotary step and return all-trunks-busy tone. The vacant levels may have trunks assigned to them at a future date.

Exercises (437):

1. Linefinder switch 10 is connected to selector switch 13 in bay 101, shelf B. What information is contained in the three sections of the linefinder switch tag?
   a. Top - __________.
   b. Middle - __________.
   c. Bottom - __________.

2. Connector switch 15 is most probably normally accessed from selector bay 103 A; bank position vertical 3, rotary 5. What information is contained in the three sections of the connector switch tag?
   a. Top - __________.
   b. Middle - __________.
   c. Bottom - __________.

3. Selector switch 47 is connected back-to-back with linefinder 15 in linefinder bay 3, shelf A. What information is contained in the three sections of the selector switch tag?
   a. Top - __________.
   b. Middle - __________.
   c. Bottom - __________.

4. What is connected to the banks of the selector in shelf F of bay 102 (fig. 6-4) that is stepped vertically 5 and rotary 4?

5. What is connected to the selector banks in shelf G of selector bay 101 (FO 10) vertical level 1, rotary position 2?

6. What equipment (FO 10) is connected to OGT terminal block terminals 221 through 240?

6-3. Call Tracing Procedures

The purpose of call tracing is to determine either the calling number or the called number. There is a need for tracing a call for security purposes, emergencies, fire, or troublesome calls; but it is *probably* used most often in troubleshooting.

Three switches (depending upon the size of the exchange) are required to complete a routine call—a linefinder, a selector, and a connector. A linefinder automatically finds the calling line and connects it to a selector that is tied to that particular linefinder.

The selector returns dial tone to the calling party, indicating that the selector is seized and ready to receive the first digit of the called party's telephone number. The selector provides a means for the calling party to choose the connector group in which the line to be called appears. The first digit in the called party's telephone number corresponds to the group that he is in, and the wipers of a selector are stepped to a level which corresponds to the number of that group.

After the selector has been stepped vertically to the desired level, it steps rotary automatically, searches for and seizes a trunk leading to an idle connector.

In an 800-line exchange, equipped with 200-point linefinders and 200-point connectors, the subscriber's telephone number consists of four digits. A selector takes the first digit for group selection. The 200-point connector takes the remaining three digits. The second digit of the telephone number is 1 or 2 and is used for bank selection. The third digit steps the wipers vertically, and the fourth digit steps the wipers rotary onto the called line.

The last two digits of a subscriber's telephone number always corresponds to the level and rotary position of his line appearance in the bank multiple of the connectors which serve his group. For example, if a connector has to step up 7 and in 2, the last two digits in the telephone number are 72.

The position of a subscriber's line appearance in the linefinder banks may not correspond with the last two digits of his telephone number. This is due to linefinder grouping and the bank multiple arrangement for preferential hunting.

Tracing a call is the procedure for determining which linefinder, selector, and connector were used to complete a call and for determining the telephone number of the calling subscriber or the called subscriber, or both.

438. Given several representative call tracing situations, and using foldout 10 as required, specify the necessary actions and sources of information to determine the called or calling number.

Determining Telephone Numbers. A calling subscriber's telephone number can be determined at the linefinder which seized his line when he originated the call, if you can find that particular linefinder. In a like manner, a called subscriber's telephone number can be determined at the connector which completes the interconnection between the two parties, if you can find that connector.

It will probably be easier to figure out the telephone number by first determining the units and tens digits, then determining the hundreds digits, and finally, the thousands digits. This is the procedure:

The last (unit) digit. The last digit of a telephone number is found by counting the number of rotary steps the wipers have taken to reach the first line appearance.

The next-to-last (tens) digit. The next-to-last digit of a called party's telephone number can be determined by counting the number of vertical steps the connectors wipers have taken.

The tens digit of the calling party's number is found in a similar manner at the linefinder bank. However, preferential hunting must be taken into consideration. If the linefinder in use is in the A group, count up to find the tens digit. If it is a B group linefinder, count down from the top of the bank to determine the tens digit.

Switch bank (hundreds digit). You must be able to tell which bank, upper or lower, the call is in in order to determine the hundreds digit.

To determine the bank in the connector (called number), you must remove the cover of that connector and observe the relays. If the K relay is operated, the call is through the upper bank to the 200 group, and the hundreds digit will be a 2. The K relay is the bank (or wiper) selection relay, and it will operate if the calling party dials a 2 for bank selection.

NOTE: Do not touch the armature of the K relay. Only look to see if it is operated. Check the first set or last set of contacts. Both sets are made when K is operated.

If the Key relay is not operated, the call will be through the lower bank, and the hundreds digit of the called party's number will be 1 (100 group).

To determine upper or lower bank in the linefinder (calling number), short-test jacks 3 and 4. Check the

LB (lower bank) lamp on the end of the linefinder shelf. If it lights, the call is in the lower bank; if not, it is in the upper bank.

NOTE: The test jacks and wiper cord terminal strip are mounted on the switch lower cover plate near the top and to the right of the bank assembly.

The terms shelf and group (4100-4200) or (5100-5200) have the same meaning, in a sense, since each individual shelf of linefinders and each shelf of connectors serve one particular group of subscribers.

The procedure outlined in the preceding paragraphs is one way to determine the telephone number of a subscriber who has originated a call (the calling party), and the telephone number of a subscriber who has been called (the called party). It can be done differently—perhaps by determining the thousands digit first (the group), then the hundreds, or second digit (bank) next, then each successive digit.

. The fact still remains that the called number can be determined at a connector and the calling number can be determined at a linefinder—when you find *the* linefinder or *the* connector that was used to make the interconnection.

To expedite tracing calls to determine telephone numbers, and for troubleshooting, it is important that you know the relationship and arrangement of all of the switching equipment in the central office. You will need to interpret switch tags and bay cards, which we have covered earlier.

Procedure. A call can be traced either forward or backward. For example, you could start by determining the calling party's number at the linefinder. You would then proceed to the specific selector by reading the tag on the linefinder. Then determine which bank contact set the selector's wipers are on. Next, you would find the connector by referring to the space on the bay card which corresponds to the selector bank contacts which were used. Always be sure to use the proper section of the bay card.

The first digit in the called party's number will be the same as the bank level used in the selector. The other three digits of the called party's number will then be determined.

When tracing backwards from called party to calling party:

First, determine the called party's telephone number at the connector.

Next, read the switch tag on the connector. The switch tag will indicate from which level and rotary position a selector has seized the connector. The connector switch tag will also indicate in which particular shelf and bay the selector is located. See the connector tag, figure 6-5. For example, if connector number 1 (fig. 6-5) has been used to complete a call, one of the selectors in bay 102, shelf E, will be stepped up 5 and in 1. Your next step then would be to find a selector in shelf E of bay 102 that has been stepped up 5 and in 1.

NOTE: If you cannot find a selector in shelf E that has been stepped to that position up 5, in 1, you must refer to the bay card and/or DTA drawing to determine what other selector shelves have access to that particular connector.

After you have found the selector that was used in the switch train (the one that seized the connector), read the switch tag. The switch tag on the selector will indicate which linefinder is connected back-to-back with that selector. The tag will also indicate which linefinder bay and shelf the linefinder is in.

You can determine the calling party's number after you locate the linefinder.

Not all of the calls that you trace are from a linefinder through to a connector. Some calls are from or to fire repeaters, city trunks, information trunks, etc. The procedure, however, is the same. The miscellaneous trunk and switching equipment are all identified with switch tags; the information they contain is similar to that found on connector switch tags.

Exercises (438):

1. The calling party, number 4217, got hung up in the exchange when he was dialing. What actions do you take, at the linefinder shelf, when tracing the call?

2. When tracing a call back from a connector, you do not find a selector in the shelf and bay indicated by the connector switch tag stepped to the proper vertical level and rotary position. What do you do then?

3. How do you determine the hundreds group for linefinder and connector switches when you are tracing calls?

4. Assume that the bay card for selector bay 101, shelf G, is destroyed. Use foldout 10 to determine what equipment a selector in that bay and shelf is connected to when it is stepped vertical 4 and rotary 4.

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Answers for Exercises

CHAPTER 1

References:

400 - 1. The linefinder is a nonnumerical (fully automatic) switch.

400 - 2. The linefinder is connected directly (back-to-back) to the succeeding switch.

400 - 3. A subscriber going off hook operating his line relay causes the linefinder to operate.

400 - 4. The combined line and cutoff relay has three windings, one of which holds it operated fully.

400 - 5. The purpose of the distributors is twofold: (1) to preselect the next idle linefinder in the group and (2) to provide connections between a linefinder and group relays during linefinder operation.

400 - 6. The distributor steps upon completion of linefinding action by the switch it is stepped to.

400 - 7. There is one distributor per linefinder group, and there are two groups per linefinder shelf.

400 - 8. The banks of one linefinder group in the shelf are wired from 1 to 0 vertically; while the banks of the other group are wired 0-1 vertically, for preferential hunting.

401 - 1. Distributor.

401 - 2. Level A, Guard; Level B, Finder Start; Level C, Vertical Stepping; Level D, Test 1 for Vertical Level; Level E, Lower Bank Cut-Through; and Level F, Upper Bank Cut-Through.

401 - 3. The distributor is a 25-point rotary switch with six levels; whereas the rotary line switch has only three levels.

401 - 4. A line relay and linefinder connect the calling telephone to the first central office equipment unit.

401 - 5. The linefinder and group distributor equipment connect the calling telephone to an idle selector trunk.

401 - 6. Distributor.

402 - 1. The B3 and H3 relays.

402 - 2. To make and break the path of the vertical magnets during vertical stepping, and, also, to prevent overstepping of the switch.

402 - 3. The N3 relay. To indicate to the equipment that a linefinder is available for use.

402 - 4. Contacts 8T and 9T of the P3 relay close the operating path of the D3 relay, which operates to ground when the vertical wiper steps to the vertical bank marked with ground.

402 - 5. Contacts 1 and 2 of relay C3 close a path for a delayed alarm (LF Start), and contacts 3 and 4 of relay C3 close the operating path of relay P3.

402 - 6. When line relay 41 operates, the linefinder steps to the fourth vertical level. The reason it does not step on the first vertical level is that the ground on the vertical bank contact is of too high a resistance.

402 - 7. The selector is preseized to provide faster dial tone and service to the subscriber. It is preseized when contacts 12 and 13 of relay B close a loop across the tip (+) and ring (−) leads to the first selector. The 500 winding of relay D is the loop placed across the leads to the selector.

402 - 8. Because it is completed through a delay circuit.

402 - 9. If the N3 relays are not operated, the linefinder equipment does not, because all of the linefinders are busy or out of service, or the shelf does not have power.

403 - 1. The line relay of the called party is operated fully from ground in the connector, thus opening the path to the C3 relay in the group relays.

403 - 2. Either the A or D relay (depending upon which hundreds group is calling) remains operated in the linefinder during conversation.

403 - 3. The interrupted operation of relay A3 in the group relays controls the rotary stepping, as well as the vertical stepping, of the linefinder and nothing in the group relays.

403 - 4. If the next linefinder in line (on the banks of the distributor) is not idle, ground in the busy linefinder is extended through the A-level contacts of the distributor to the motor magneto. This operates and opens the motor magnet interrupter contacts, which causes the motor magneto to release and step the distributor wipers in the bank.

404 - 1. When the calling party hangs up, the holding ground from the succeeding equipment is lost, causing either the H or D relay in the linefinder to release. When the A or D relay releases, it closes the path to the release magnets; the release magnets remain operated until the VON spring contacts are opened by the return to normal of the switch.

404 - 2. The cam switch of the linefinder operates during the eleventh rotary step, on any vertical level, closing a path to the release magnets.

404 - 3. The operating circuit of the N3 relay is connected in parallel through the VON springs of each linefinder in a group, so that when no linefinders are available, no attempt is made by the group relays to process the calls.

404 - 4. Nothing prevents the distributor from stepping off a busy linefinder, regardless of a transfer. The path to the motor magnets is not controlled by the operation of relay E3.

405 - 1. The vertical or rotary interrupter is shorted, causing A3 to operate and lock up. The leads for the interrupters for all 20 switches in a linefinder shelf are multipled (in parallel) to both sets of group relays.

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Since relay A3 is locked up, no vertical stepping can take place in that shelf.

405 - 2. The most probable electrical cause is an open tip or ring wiper cord due to a cold solder joint or a physical break in the wiper cord. Correction would amount to resoldering the connection or replacing the wiper cord. The most probable mechanical cause would be an upper bank line wiper that is out of adjustment. Readjustment of the wiper would correct it. With the line wiper out of adjustment, the calling party's loop cannot hold the A relay in the selector operated and the selector releases.

405 - 3. The electrical problem is that relay H3 is releasing prematurely, because relay B3 is out of the adjustment. Readjusting relay B3 will correct the problem.

405 - 4. Contacts 8 and 9 of relay H3 in the A group relays are shorted. Correction is not necessarily cut and dried. Chances are that the contact terminals are touching, but they could also be shorted by the back cover. If they are physically touching, bending the contact terminal will cure it. If it's the back cover, then the cover must be insulated.

CHAPTER 2

406 - 1. The first selector.
406 - 2. Telephone selectors may be identified as first, second, third, incoming, or special selectors.
406 - 3. Each selector responds to one dialed digit.
406 - 4. A selector circuit can be connected to restrict service to certain lines.
406 - 5. Selector banks are connected to wipers of the next switch in the train.
406 - 6. A selector bay supports 100 switches.
406 - 7. Shelf H in bay 101 supports switch 75.

407 - 1. Relay A.
407 - 2. Relay B.
407 - 3. Relay A.

408 - 1. At the first dial pulse spring break, relays B, C, E, and the vertical magnet are operated.
408 - 2. An electrical shunt prevents the relay F from operating.
408 - 3. The Strowger switch steps because of electrical and mechanical actions. Electrical current operates relays and switch magnets. The magnets raise the shaft which mechanically moves the wipers and the VON switch. Further, the shaft's movement is controlled by mechanical devices.

409 - 1. Rotary magnet.
409 - 2. Connecting the bank contacts for each group of selectors in multiple.
409 - 3. Relay E and the rotary magnet.

410 - 1. The line bank contacts are identified as + or −.
410 - 2. C wiper.
410 - 3. Relay F.
410 - 4. Circuit resistance.
410 - 5. Relay F.

411 - 1. Relay A.
411 - 2. The C lead is grounded to hold equipment operated.
411 - 3. The linefinder operates first, followed by the selector(s) and connector.
411 - 4. The stationary detent supports the switch shaft while a conversation is in progress.

412 - 1. 10 trunks.
412 - 2. SE-3.
412 - 3. Dial tone is a steady uninterrupted tone; whereas the ATB tone is a regularly interrupted tone.
412 - 4. The C wiper for an idle trunk has ground potential; whereas a busy trunk provides no ground for the wiper.

413 - 1. Ground.
413 - 2. The release magnet.
413 - 3. Jack terminal 10, release magnet winding and shunting resistor, contacts 1 and 2 of switch 1, contacts 1 and 2 of relay B, contacts 1 and 2 of relay A, and contacts 4T and 5T of relay F.
413 - 4. The wipers are moved mechanically by the switch shaft spring.

414 - 1. Relays A and B operate to seize the selector. The operated B relay connects ground to the C wiper to hold the linefinder operated, and the linefinder, in turn, holds the selector A relay operated. Hence, if the linefinder loses its connection to ground at contacts 4 and 5 of relay B, it opens the operating circuit of selector relay A. The released relay A, in turn, releases relay B. Thus, when a selector operates and releases immediately, check the condition of contacts 4 and 5 of relay B.

414 - 2. The rotary magnet operates following the operation of relays B and E. Accordingly, contacts 4 and 5 of relay B and 3 and 4 of relay E must make good connection if the rotary magnet is to operate. Also, if relay E failed to operate because of defective contacts at the VON switch or at contacts of the C relay, there would likewise be no rotary stepping. This trouble symptom, then, requires that you inspect these listed contacts.

414 - 3. Release of the selector is the result of restoration of all the circuit components. We have noted that the F relay and the VON switch remain operated during the conversation; therefore, they must release to return the equipment to normal. The F relay is released when the connector circuit B relay disconnects ground from the C lead. Following the F relay release, the release magnet operates because of made contacts at the operated VON switch and released contacts at relays A, B, and F. Thus, if any one of these sets of contacts is dirty or maladjusted, the release magnet cannot operate. Again, we encourage you to look first at the mechanical devices in the circuit to correct what appears to be an electrical problem in this telephone equipment.

CHAPTER 3

415 - 1. The regular, trunk-hunting, and executive right-of-way service connectors provide ringing, ringback, and busy tone to the line loop.
415 - 2. The regular connector responds to the last two digits dialed.
415 - 3. The regular connector is so connected that it provides service to one line. In contrast, the trunk-hunting connector serves more than one line.
415 - 4. Regular connectors and a test connector are installed on shelf j in connector bay 102.
415 - 5. The regular connectors are installed to the right of the test connector and are connected to a ringing source. The test connector is at the left of the shelf and is not connected to the ringing source.

416 - 1. The connector B relay connects ground potential to the C lead of the trunk to hold the preceding switches operated.
416 - 2. The connector A relay contacts 2 and 3 complete the operating circuit for relay B. Contacts 1 and 2 partially complete the operating circuit for the release magnet.

416 - 3. A subscriber lifts the handset to seize the linefinder, then dials numbers. The first digit he dials seizes a selector, and the selector in turn searches the associated connector trunks and connects the calling line to the idle connector A relay. Thus, this relay operates to complete the operating circuit of the B relay.
416 - 4. Selector control bank contacts are connected in multiple, and a grounded connector wiper is thereby busy to all searching selectors.

417 - 1. Since the connector is controlled by the last two dialed digits, the operating circuit of relay A is interrupted four times for the TENS digit and twice for the UNITS digit.
417 - 2. The VON switch contacts 1 and 2 complete the release magnet operating circuit, contacts 3 and 5 complete the operating circuit for relay C and the vertical magnet, and contacts 4 and 5 also complete an operating circuit for relay C and the vertical magnet.
417 - 3. The connector vertical magnet operates three times when the number dialed is 2135.
417 - 4. Relays A, B, and C.

418 - 1. The dialed UNITS digit 2 controls the rotary stepping of the connector.
418 - 2. Relays A, B, and E.
418 - 3. Wiper C connects with lead CN, wiper − touches lead −N, and wiper + mates with +N following connector rotary switch operation onto an idle line.

419 - 1. A, B, C, E, H, F, and D.
419 - 2. Contacts 5T and 6T of relay H.
419 - 3. Contacts 3B and 4B of relay H and 8 and 9 of relay F.
419 - 4. Relay A and contacts 7, 8, 10 and 12 of relay D are in the calling telephone talking battery circuit.
419 - 5. Relay D, contacts 4 and 5 and 7 and 9 of relay F, contacts 5T and 6T and 7T and 8T of relay H, and the − and + wipers are in the called telephone talking battery circuit.
419 - 6. Line reversal by the connector provides a supervisory signal to an operator.
419 - 7. AC.

420 - 1. Relays A, B, D, F. and H.
420 - 2. Relays A, B, and E.
420 - 3. Relays A, B, E, D, H, and F.
420 - 4. Relays D, A, B, H, E, and F.
420 - 5. Contacts 1 and 2 and 5 and 6 of relay D, 1 and 2 of relay A, 1 and 2 of relay B, and 10 and 11 of relay F.

421 - 1. Grounded connector bank contacts for line 10 operate the G relay.
421 - 2. Relays A, B, and G.
421 - 3. The calling subscriber must replace the handset on the cradle to release the Strowger equipment following reception of busy tone.
421 - 4. Relays A, B, and G.

422 - 1. Tracing the rotary magnet circuit, shown in foldout 3, reveals that the following made contacts complete its operating path: contacts 3T and 4T of relay H, 1 and 2 of relay G, 1 and 2 of relay C, 4 and 5 of the VON, 2 and 3 of relay B, and 1 and 2 of relay A. Thus, any one of those sets could be defective. Of course, if the B relay or the VON switch were to release early, they could likewise prevent the rotary magnet from operating. We are considering that relay contacts are the problem, thus need to be corrected.
422 - 2. Giving thought to the symptom reported should also result in additional conclusions. Since the called party answered the calling party's question or comment, we can conclude that the calling party has transmission battery, the two 2MF capacitors in the connector's transmission circuit are good, the connector wipers are making with the bank contacts satisfactorily, and the called subscriber line and telephone receiver circuit components are good. Further, we can conclude that the trouble is either in the called party's telephone transmitter or is in the connector talking battery circuit. Look at foldout 3 and consider that the trouble is in the latter. Accordingly, components that could be probable faults are contacts 5T and 6T and 7T and 8T of relay H, and 4 and 5 and 7 and 9 of relay F. An inspection of them and a cleansing of the set(s) which show buildup may correct the problem. If they are not faulty, then the called parties' subset must be checked and repaired.

CHAPTER 4

423 - 1. Relays C1, C11, and C-21 make up signal group number one.
423 - 2. The length of one cycle, of the timing circuit is five seconds.
423 - 3. The ringing machine, by means of rotating cams, puts ground pulses on the TIME 1 and TIME 2 leads of the supervisory circuit.
423 - 4. The ground pulses are one-fourth-second duration.
423 - 5. The indicator alarm fuses for Strowger offices are supplied in 1-, 3-, and 5- ampere ratings.
423 - 6. The purpose of the alarm and supervisory circuit in a Strowger exchange is to monitor certain equipment condition by means of indicator alarm fuses and shelf supervisory circuits, and when an abnormal condition exists, cause an alarm—both audible and visual—to alert maintenance personnel and to guide them to the bay shelf that is in trouble.

424 - 1. It will take about 4 to 4¼ seconds before the B-6 relay will operate.
424 - 2. The purpose of contacts 5 and 6 of relay C-11 is to shunt the high-resistance winding of relay C-1 to cause the alarm lamp to light.
424 - 3. After relay B-7 operates, a ground pulse coming in on the TIME 1 lead energizes the upper winding of relay B-6, with an opposite polarity to that of the lower winding. The magnetic fields oppose each other, and the B-6 relay releases.
424 - 4. The purpose of the capacitors in series with relay C-39 is to provide a low-resistance path to ground for the AC.
424 - 5. The major alarm bell is powered by dry cell batteries.
424 - 6. Yes, relay C-32 will operate. The lamps are in parallel with resistors to insure an operate path for relay C-32 when a fuse blows.
424 - 7. Relay B-8 releases when relay B-7 operates.
424 - 8. The release alarm lamp does not extinguish when relay B-8 releases. It stays lit because relay C-1 has a hold path through its 3 and 5 contacts.

425 - 1. Contacts (all) of relay C-35 are dirty. Burnishing the contacts will clear the trouble.
425 - 2. Relay B-8 is not operating. The causes could be dirty contacts 4 and 5 of relay B-7 or contacts 3 and 4 of relay B-6, in which case, burnishing will clear it. If it is an open coil of relay B-8 instead, then the coil must be replaced.

426 - 1. The twofold purpose of central office power equipment is (1) to convert 220 volt, 3 phase ac into dc and (2) to control the dc output for operating equipment and charging the central office battery.
426 - 2. The purpose of the ringing equipment is to provide interrupted ringing current for signalling subscribers

and ring back tone. It also provides grounds on the TIME 1 and 2 leads for the alarm and supervisory circuits. Busy tone and all trunks busy tone is also supplied from the interrupters of the ringing equipment.

427 - 1. In parallel with the output of the charger through the windings of the control reactors.

427 - 2. To monitor the output voltage of the charger, comparing it with the reference voltage, and compensating so that the output voltage remains stable, regardless of a constantly charging load.

427 - 3. 120 percent of its rated capacity. If a Flotrol is rated at 200 amps, its overload current would be 240 amps or higher.

427 - 4. The equalizing switch of a Flotrol changes the output voltage of the reference source, thereby causing the charger to regulate at a higher level.

427 - 5. The purpose of the dc contactors is this: whenever the 220 volt source for the charger is off, the contactors open contacts, and the circuit to the battery is open.

427 - 6. The filter choke eliminates the noise from the central office battery and transmission paths.

427 - 7. The output adjustment taps change the reference source voltage, either up or down, depending upon the placement of the link. Changing the voltage of the reference source causes a change in the regulated output voltage.

427 - 8. The required addition of water to the battery more than once every 3 months.

427 - 9. The D-21 relay in the ringing generator control circuit is normally operated from direct generator.

427 - 10. All of the cam contacts of the interrupter place ground potential on the associated lead when closed.

427 - 11. Relay D-21 will release, but will reoperate after ringing machine transfer.

427 - 12. Relays D-4 and D-14 serve the same ringing group (1).

427 - 13. Busy tone is dial tone, interrupted at a rate of 60 IPM and all-trunks-busy tone is dial tone interrupted at the rate of 120 IPM.

428 - 1. The charging rate is too high. The float level of the battery charger needs to be decreased.

428 - 2. There are two possible troubles: (1) relay D-8 may not be operating because of dirty interrupter cam contacts, or (2) contacts 2 and 3 of relay D-8 may be dirty. Burnishing the contacts will clear the trouble.

428 - 3. The battery that is supposed to be supplied by contacts 1 and 2 of relay D-7 to operate the ring-trip relay in the connector is not present, because the contacts are dirty.

CHAPTER 5

429 - 1. The purpose of the fire repeater is to provide subscribers a means of contacting the fire department to report fires.

429 - 2. The main function of the reverting call switch is to send ringing current to the calling instrument to check that the bells of the instrument or instruments work.

429 - 3. The pulse repeater is accessed through the banks of first selector switches.

429 - 4. The main functions of a pulse repeater are (1) to provide a low resistance path between two central offices and (2) to repeat the pulses dialed into it from the local subscriber to the distant office to step that office's equipment.

429 - 5. The fire repeater and the reverting call switch are accessed through different levels in the banks of the special second selectors.

430 - 1. Common battery and local battery subscribers have line jack appearances on the switchboard in an automatc central office.

430 - 2. The attendant's cabinet in a Strowger central office is equipped with 17 cord circuits per position.

430 - 3. Through the use of out-dial-to-line equipment or out-dial-to connector trunks.

430 - 4. At the top left panel of switchboard position 1 or at the top of the cable turning section, when it is beside position 1.

430 - 5. The primary function of a switchboard in an automatic central office is as an information center and the rendering of assistance in emergencies.

430 - 6. The operator, with respect to fire calls, may verify the call, to be sure that it is not a wrong number, and then extend it to the fire department through the fire control panel. The operator has supervision over the line and releases the line when the call is complete.

430 - 7. The circuits that are associated with the switchboard but that are not a part of its circuitry proper are: (1) common battery lines, (2) local battery lines, (3) out-dial-to-line equipment, (4) out-dial-to-connector trunks, (5) fire trunk control panel, (6) auto-to-auto repeaters, and (7) city trunks.

431 - 1. In a step-by-step telephone switching center, one fire alarm buzzer is provided, regardless of the number of fire trunks.

431 - 3. In order for the attendant to be aware that a fire alarm call has come into the telephone switching center, the step-by-step special second selector to an idle fire repeater will process the call, provided that the fire repeater has a negative battery potential at the RLS TRK (release trunk) lead.

431 - 2 Relays B, D, and G in a step-by-step fire repeater circuit are not released until the attendant operates a release switch. Because of this, step-by-step telephone switching center personnel can trace operated equipment which has processed a call through a special second selector, first selector, and the linefinder. Thus, they can determine the directory number of the calling station. The line record card for this line number will indicate the location of the station.

431 - 4. To extend the fire call, the switchboard operator operates the FIRE switch momentarily. This action grounds leads C1 and DC. Ground on the C1 lead operates the G relay, which holds operated through its 1 and 2 contacts to ground on the DR lead. Ground on the DC lead operates relays B and D, which operate and hold operated through their own contacts. Relay G closes the transmission path to the fire department when it operates. When relay B operates, interrupted ringback tone is sent to the calling party. Relay D, when it operates, closes a path to the bell in the central office.

431 - 5. When the fire department answers the call, a loop is closed across tip and ring line to the fire department, which operates relay F in the trunk circuit. Relay F operates and holds operated to ground on the DR lead through its X (1 and 2) contacts. Contacts 6 and 7 of relay F break and stop ringback tone to the calling party. The line lamp LM2 goes out, and the supervisory lamp LM1 lights. Relay C operates through the loop of the fire department's instrument.

432 - 1. A pulse repeater is used in a telephone switching center to repeat the dial pulses of the calling telephone over a trunk between two switching centers.

432 - 2. Telephone pulse repeaters are used only when it is necessary to transfer calls from one switching center to another telephone switching center.

432 - 3. A call from a distant telephone switching center is connected to an incoming selector.

432 - 4. A ground potential must be connected to the C lead of a step-by-step selector, linefinder, and line circuit if the equipment is to remain operated. This ground is provided by succeeding circuits as the call is processed. Therefore, seizure of a step-by-step pulse repeater must cause a ground potential to be connected to a C lead, which terminates at the preceding selector bank.

432 - 5. Relay A of a step-by-step pulse repeater is under the direct control of the dial. Therefore, relay A serves as the dialing relay for the step-by-step pulse repeater circuit. Relay C has also been referred to as a dialing relay, but for the incoming selector of a distant switching center. Relay C becomes the second dialing relay for the distant switching center, since relay A is the normal dialing relay for a step-by-step selector.

432 - 6. Negative battery potential at the C lead identifies a step-by-step pulse repeater as being idle. This potential is connected at the winding of relay G in the pulse repeater for the C lead terminated at the local selector bank and is connected to the winding of relay E in the pulse repeater for the C lead that is terminated in the preceding selector bank.

432 - 7. Operating the busy switch of a step-by-step pulse repeater completes the operating circuit for relay E. Operated relay E connects ground to the selector bank, which makes this repeater busy to any future calls as long as the busy switch is operated. This permits the repeater to be checked or repaired.

432 - 8. Relay E. On an incoming call, relay E in the pulse repeater operates from ground returned from the contacts of relay B in the incoming selector.

432 - 9. When relay E in the pulse repeater operates, it lights the busy lamp on the switchboard and marks the selector banks with ground, to prevent seizure while it is in use.

433 - 1. When the special second selector switches through, the subscriber's line loop is placed across tip and ring of the reverting call switch. This closes the path for relay A. Contacts 3 and 4 of relay close the operate path for relay B. Contacts 1 and 2 of A open, preventing the premature operation relay D. Contacts 6 and 7 of relay B close a hold path for relay B.

433 - 2. When relay D operates, its contacts 2 and 3 and 5 and 6 close a path for ringing current to the subscriber's line. D relay contacts 7 and 8 close a path for the E relay, which is a timing relay.

433 - 3. When the installer lifts the handset from the cradle, the J relay operates, closing a path to operate the H relay. The H relay's contacts 1 and 2 close a holding path for itself. Its 3 and 4 contacts open the path for relay D; its 5 and 6 contacts open the hold path of relay [illegible] which goes on slow-to-release; and contacts 7 and 8 remove ground from the ringing machine start lead.

433 - 4. When the installer hangs up the phone the second time, relays A, B, and H release, thereby releasing the reverting call switch.

434 - 1. The condition of the sleeve of the line jack determines whether or not the cord circuit will supply transmission battery to a line circuit.

434 - 2. Its 4 and 5 contacts close a path for LM1, the line lamp.

434 - 3. The A relay in the common battery line circuit operates when the contacts of the line jack make, due to a plug being put in it.

434 - 4. When a connector is busy, the busy lamp, above its line jack appearance on the switchboard, is lit.

434 - 5. Contacts 1 and 2 of the operated, selector level 0 trunk, A relay close a path from ground to light the incoming line lamp on the switchboard. Contacts 5 and 6 of the A relay close a path to operate the circuit's B relay.

434 - 6. When the operator plugs a cord into the line jack of a 0-level trunk, the cord circuit will provide transmission battery to the calling party. The sleeve of the line jack has a nonresistance ground on it, with a plug inserted in the line jack.

434 - 7. The path from tip of the answer cord, through the impulse springs of the dial to the ring of the answer cord is: (1) tip of the answer through contacts of the RING ANS key, (2) through contacts 3T and 5T of an operated H relay (cord circuit), (3) through contacts 4T and 6T of an operated D relay (position circuit), (4) through contacts of an unoperated TRK OFF key, (5) through contacts 1T and 2T of the C relay (position circuit), (6) through the contacts of the dial's pulse springs, (7) through contacts of the SPLIT CALL key, (8) through contacts 6T and 5T and 1B and 2B of the operated C relay (position circuit), (9) through other contacts of the SPLIT CALL key, (10) through contacts 5B and 6B of the operated D relay (position circuit), through 1B and 3B of the operated H relay (cord circuit), and through other contacts of the RING ANS key to the ring of the answer cord.

434 - 8. The TALK key *must* be operated prior to operating the DIAL ANS key when dialing over the answer cord. This order of operating the keys is a must for the following reasons:

a. Relay H in the cord circuit must be operated.
b. The operate path for relay H is through contacts of an operated G relay (cord circuit) and contacts of an operated D relay (position circuit); it then has a hold path through its own contacts to contacts of an operated D relay.
c. The operate path for relay G (cord circuit) is through contacts of an *unoperated* D relay (position circuit).
d. The G relay in the cord circuit must operate at least long enough for the H relay (cord circuit) to operate and then hold, operated.

435 - 1. Contacts 9 and 10 of the C relay in the cord circuit are dirty.

435 - 2. This trouble has to be in the position circuit, since it affects all of the cord circuits. When the DIAL ANS key is operated, relay D of the position circuit should operate. But it doesn't. Dirty contacts in the DIAL ANS key could be the problem, but dirty contacts 1 and 2 of the F relay could also be the problem. Burnishing the contacts should clear the trouble.

435 - 3. If contacts 1 and 2 of the A relay in the common battery line circuit are dirty, the line lamp will not light, and the B relay will not operate on incoming calls.

435 - 4 The selector releases, because contacts 5 and 6 of the B relay in the selector level D trunk are dirty and a holding ground is not getting back to the selector.

435 - 5. The most probable reason that the reverting call switch released is that the B relay did not have a hold path. The most probable cause for relay B not holding is dirty or unmade contacts 5 and 6 of the H relay.

435 - 6. The most probable cause for nothing happening when the FIRE button is operated is dirty contacts of the FIRE button, making it impossible for relays B and G to operate.

CHAPTER 6

436 - 1. The test handset should be used initially to test a selector for erratic vertical stepping. Because it can test the operation of the A relay for a high-resistance loop condition almost as well as the varying machine can. The varying machine must warm up for 30 minutes prior to testing with it.

436 - 2. The varying machine can test a selector under high resistance as well as for leakage line conditions, and the pulses are put out at a more precise time rate than the test handset.

436 - 3. The false trip test is performed during the silent period, with the type 26A switch tester, between ringing cycles.

436 - 4. Operating the FALSE TRIP key places a 2300-ohm resistance short across tip and ring of the test line. This resistance short should not cause the ring trip relay in the connector under test to operate.

437 - 1.
- a. 101.
- b. 10.
- c. 13.

437-2.
- a. 103A.
- b. 15.
- c. 3-5.

437 - 3.
- a. LF-3-A.
- b. 47.
- c. 15.

437 - 4. A selector stepped vertically 5 and rotary 4 in shelf F of bay 102 is connected to connector switch 4 in connector bay 1, shelf C.

437 - 5. Outgoing trunk 362 is connected to the selector banks of shelf G, bay 101, vertical level 1, rotary position 2.

437 - 6. Connectors 1 through 20 in connector bay 1, shelf B are terminated on OGT terminal block terminals 221 through 240.

438 - 1. After you find the linefinder shelf that serves the 4200 group, you look for a switch that is stepped vertical 1, rotary 7; and if you do not find one stepped that way, look in the other group of 10 switches stepped 0 vertical and rotary 7. Whichever group you find it in, you must then test for the proper hundreds group by shorting test jacks 3 and 4 of the linefinder. Since 4217 is an upper line bank number, if the lower bank lamp does not light, you have found the linefinder the calling party is using. You then go to the first selector, using the information from the linefinder switch tag.

438 - 2. You should go to the DTA drawing. This will tell you what other selector shelves have access to that particular connector switch. It will also show any reverses that may be in the multiple and the bank position in different selector shelves.

438 - 3. Determining the hundreds group of a telephone number in the linefinder equipment is a matter of shorting the 3 and 4 test jacks of the linefinder. If the lower bank lamp on the supervisory fuse panel lights, the number is in the lower bank of the number group. If the lamp does not light, the number is in the upper bank of the number group. In the connector equipment, determining upper or lower bank is done by looking at the K relay. If the K is not operated, the number is in the lower bank; and if the K relay is operated, the number is in the upper bank.

438 - 4. A selector in bay 101, shelf G, that is stepped vertical 4 and rotary 4 is, in turn, connected to connector switch 14 in connector bay 1, shelf B.

36251 03 S01 7601

SUPPLEMENTARY MATERIAL

CDC 36251

TELEPHONE SWITCHING EQUIPMENT REPAIRMAN (ELECTROMECHANICAL)

(AFSC 36251)

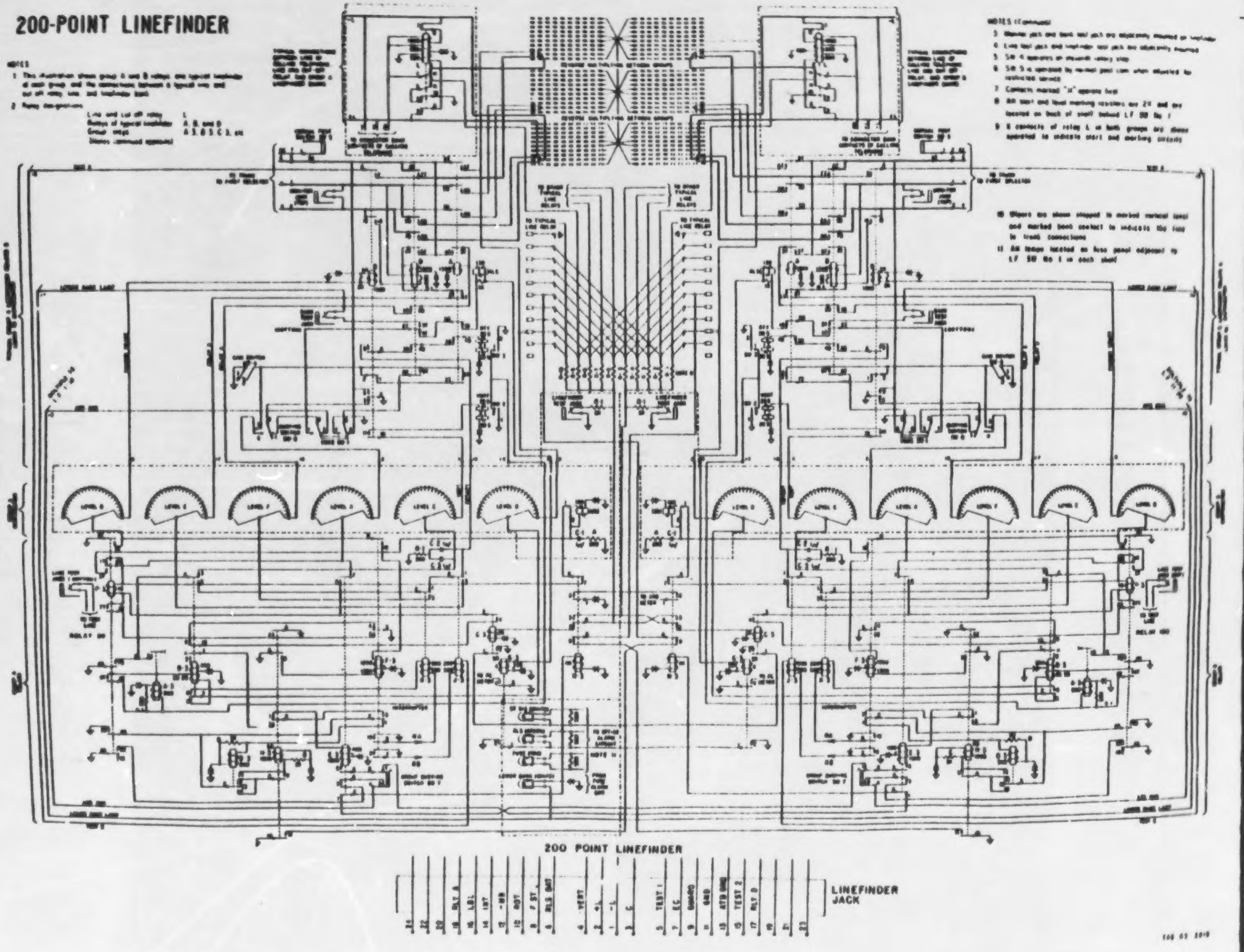
Volume 3

Foldouts 1-10

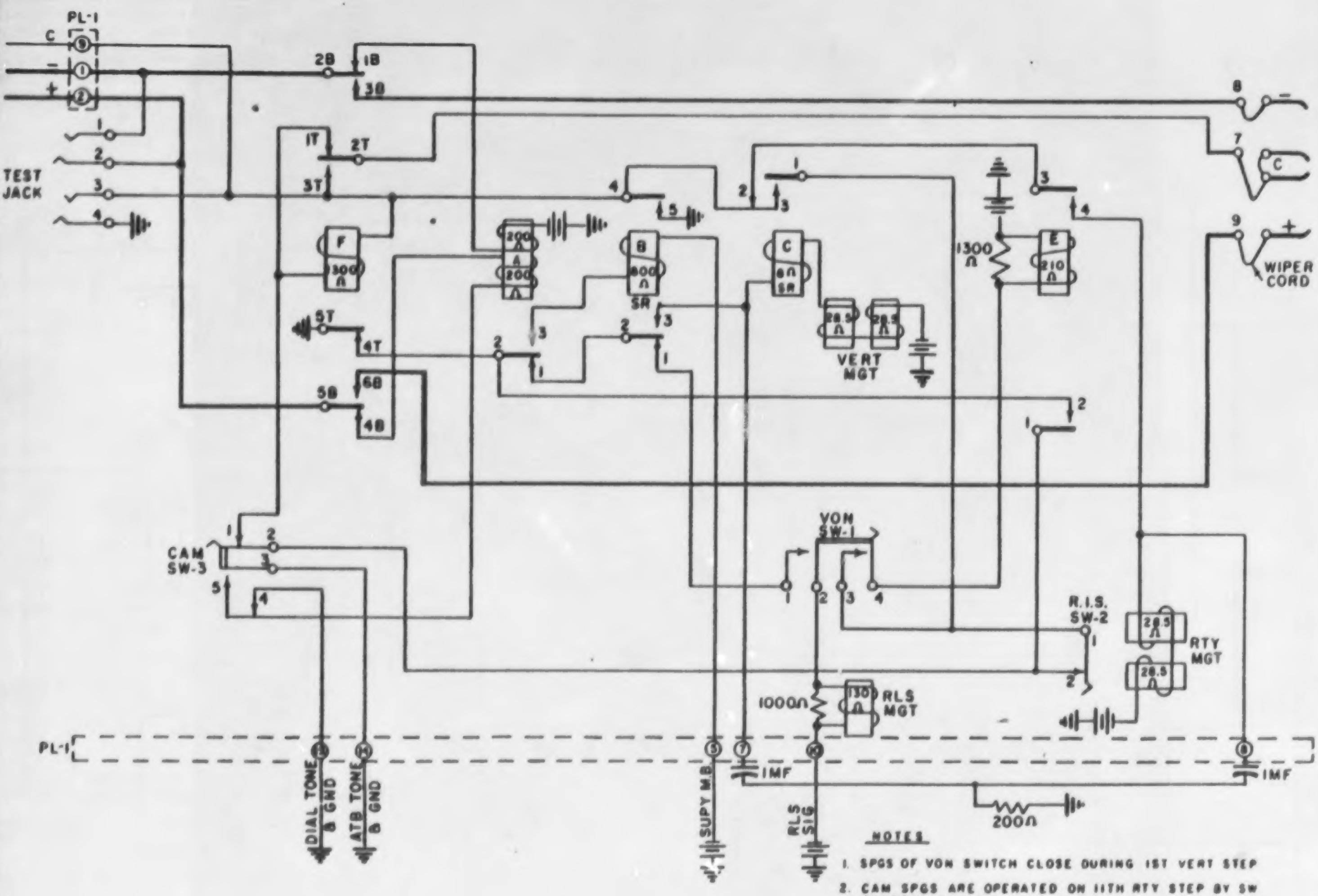
AU GAFS, ALA. (753816)1200

Extension Course Institute

Air University



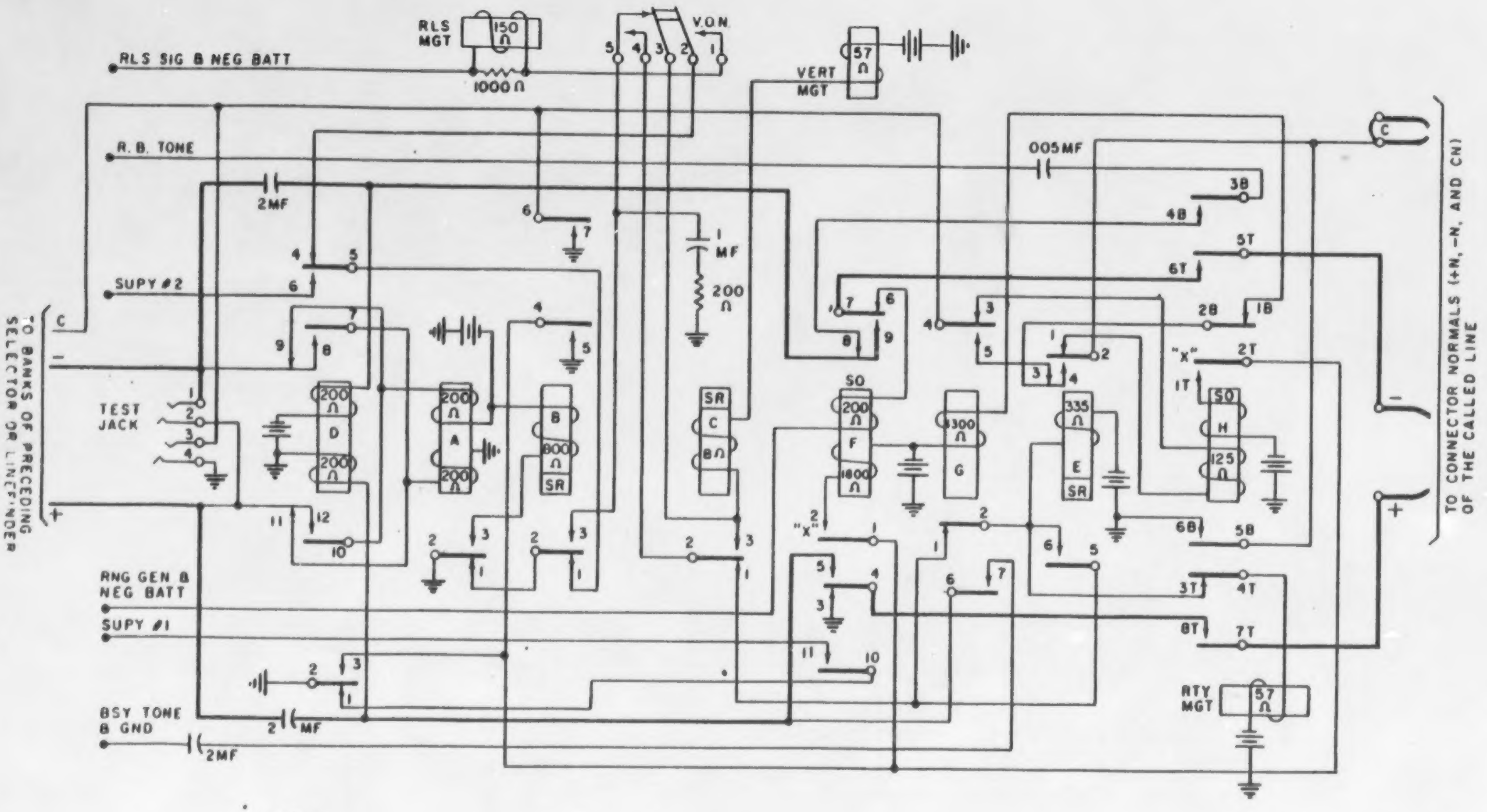
Foldout 1. 200-point Strowger linefinder circuit.



NOTES

1. SPGS OF VON SWITCH CLOSE DURING 1ST VERT STEP
2. CAM SPGS ARE OPERATED ON 11TH RTY STEP BY SW SHAFT CAM
3. DIAL TONE CONNECTION IS FOR REGULAR (LOCAL) 1ST SELECTORS ONLY; OTHER SELECTORS HAVE GND LEAD INSTEAD OF DIAL TONE AND GND LEAD
4. RELAY F OPERATES IN SERIES WITH RELAY E, BUT RELAY E DOES NOT OPERATE IN SERIES WITH RELAY F.

Foldout 2. Typical step-by-step selector.



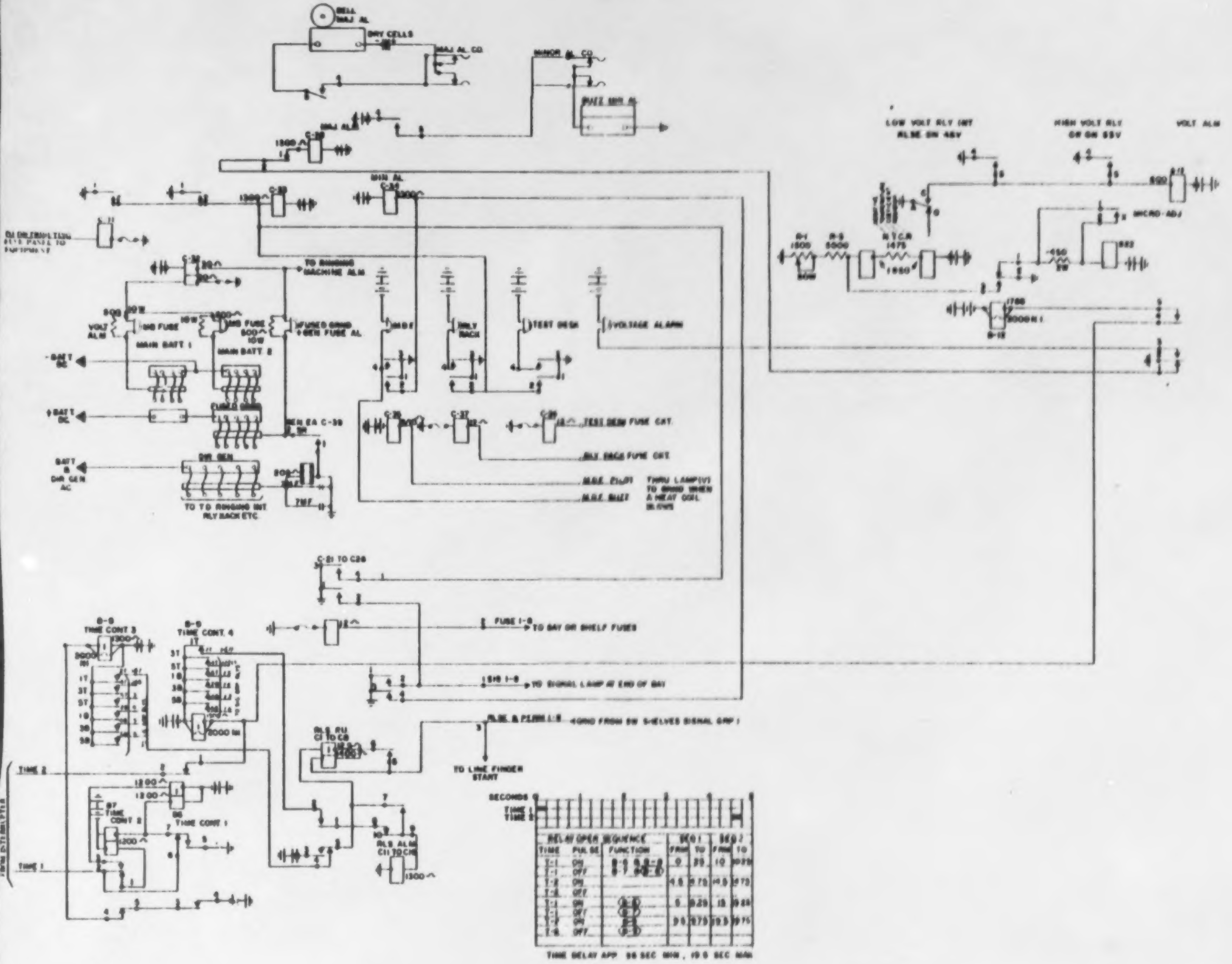
NOTES

1 "X" CONTACTS OF RELAYS F AND H MAKE FIRST

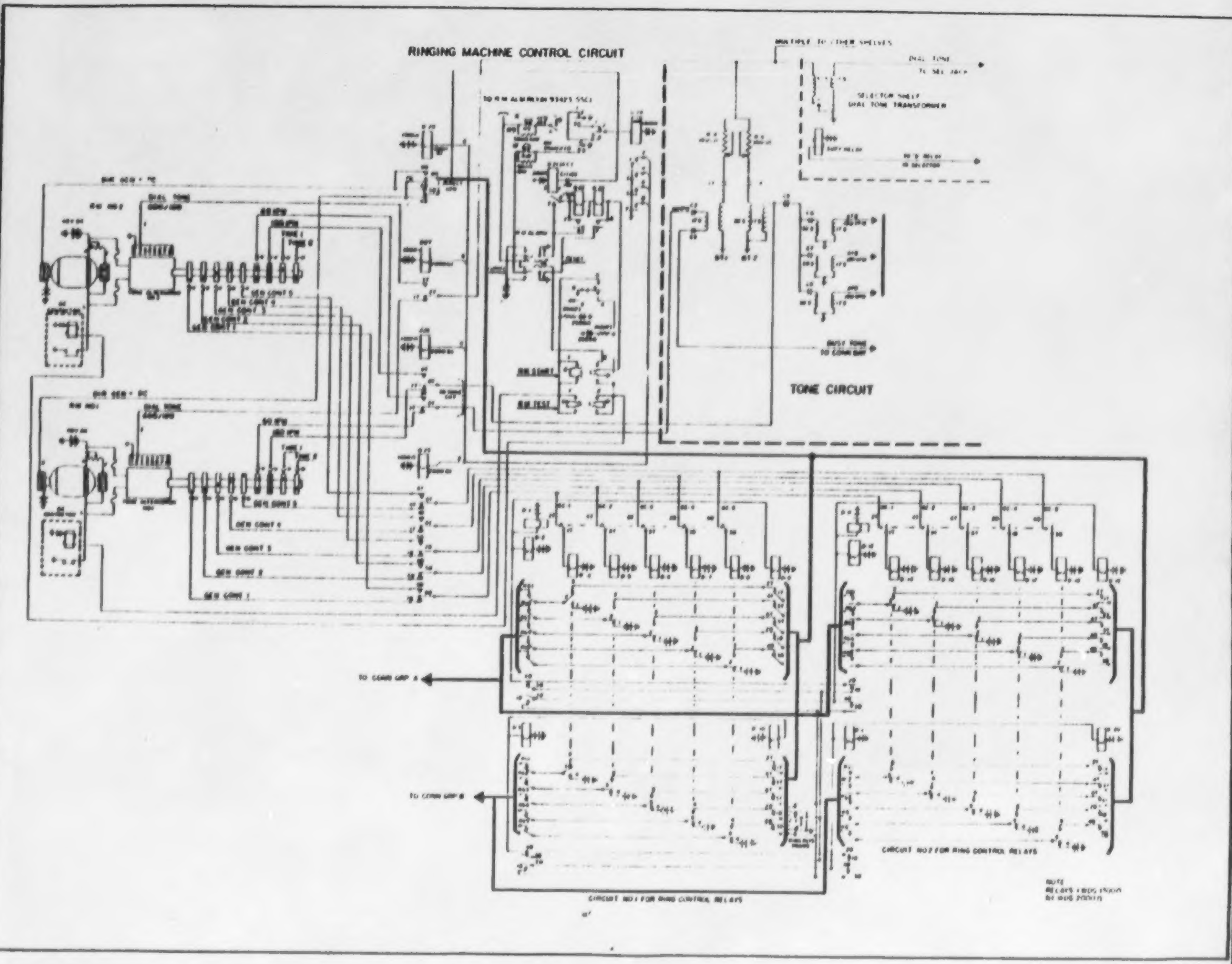
2 SUPY NO 1 AND SUPY NO 2 LEADS EACH EXTEND THROUGH A SUPERVISORY LAMP TO NEGATIVE BATTERY

3 RELAY F OPERATES ONLY WHEN DIRECT CURRENT OR DIRECT CURRENT SUPERIMPOSED WITH ALTERNATING CURRENT FLOWS THROUGH ITS 200 OHM WINDING

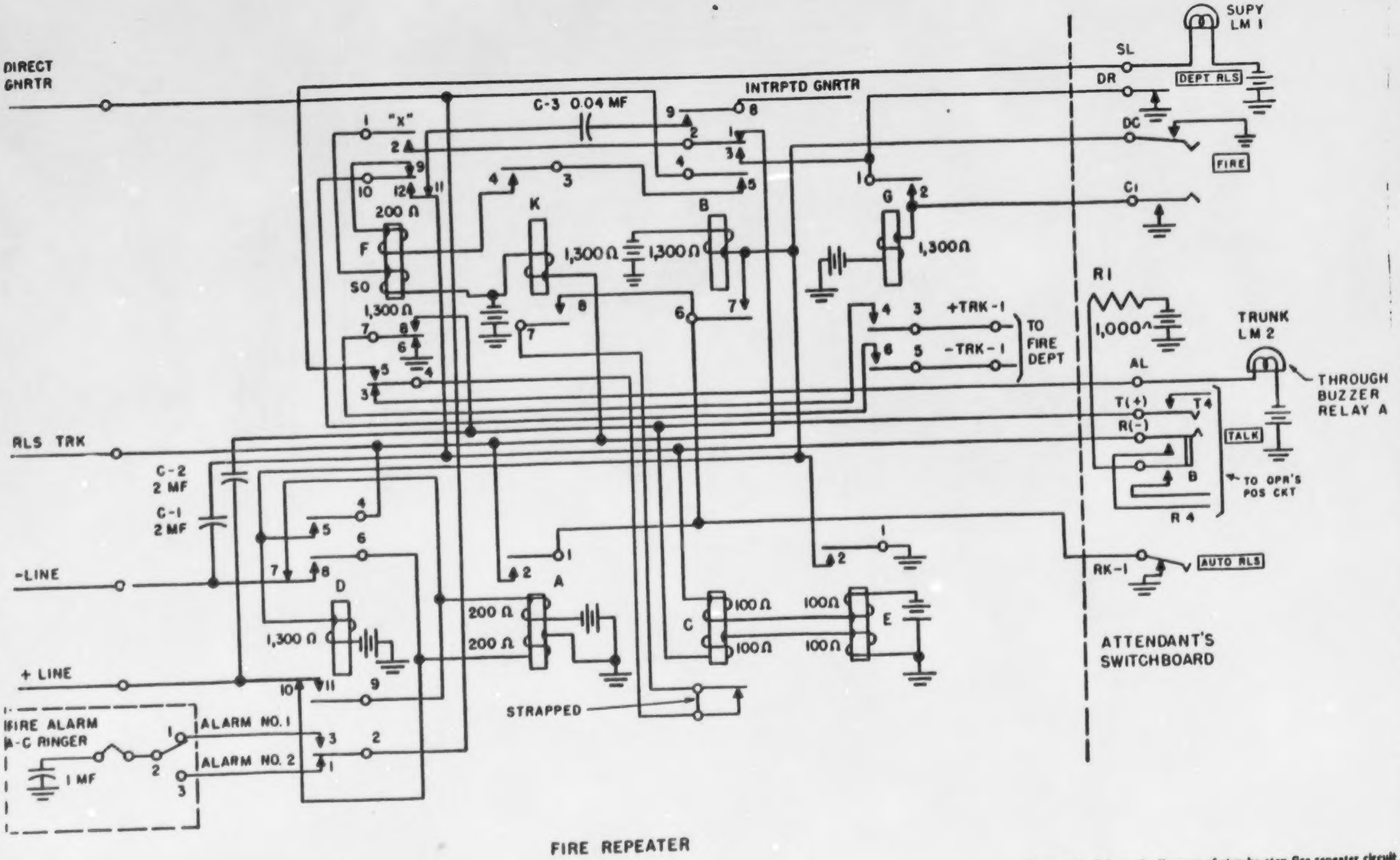
Foldout 3. 100-point step-by-step connector.



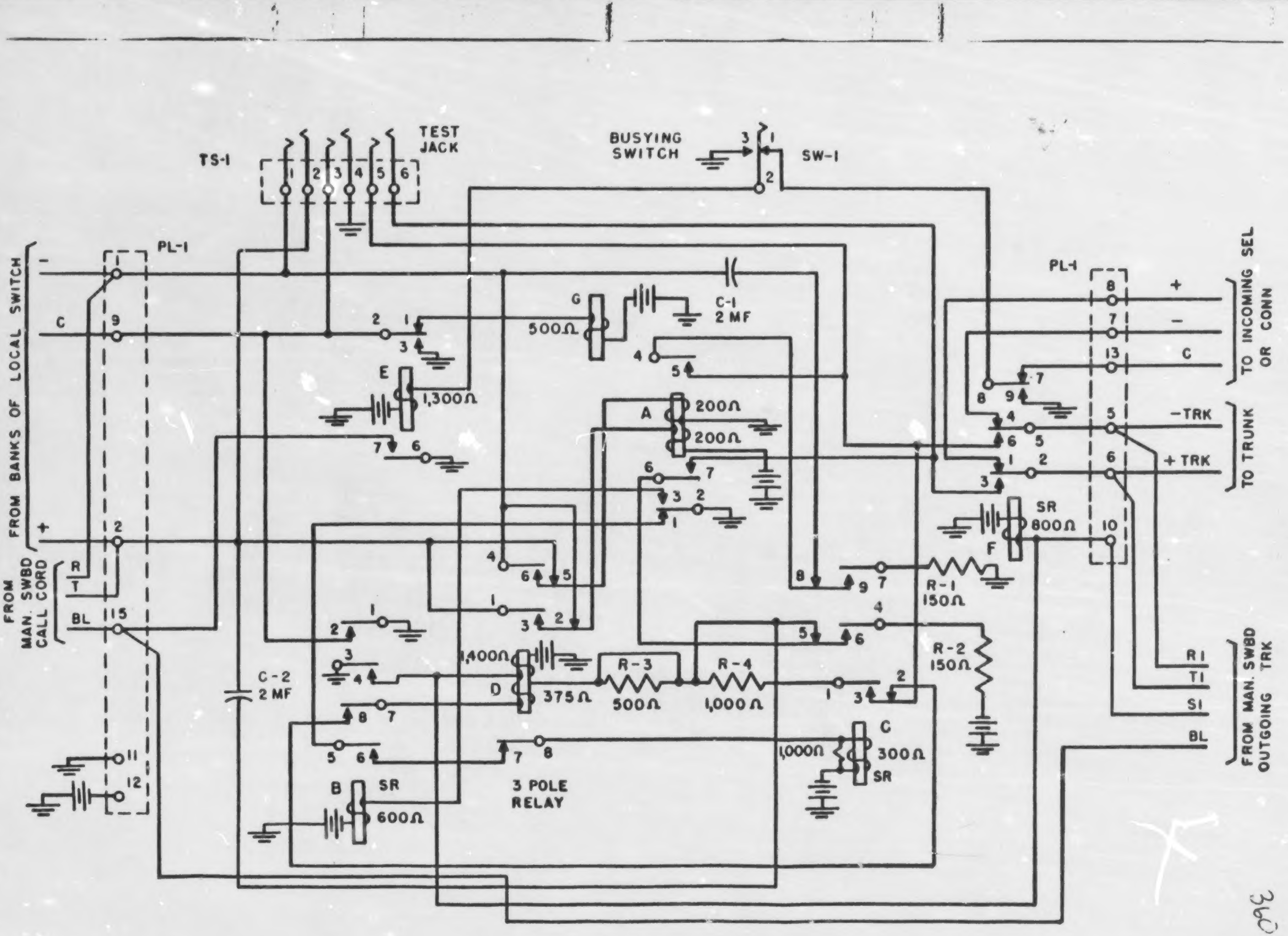
Foldout 4. Schematic diagram of step-by-step alarm and supervisory circuit.



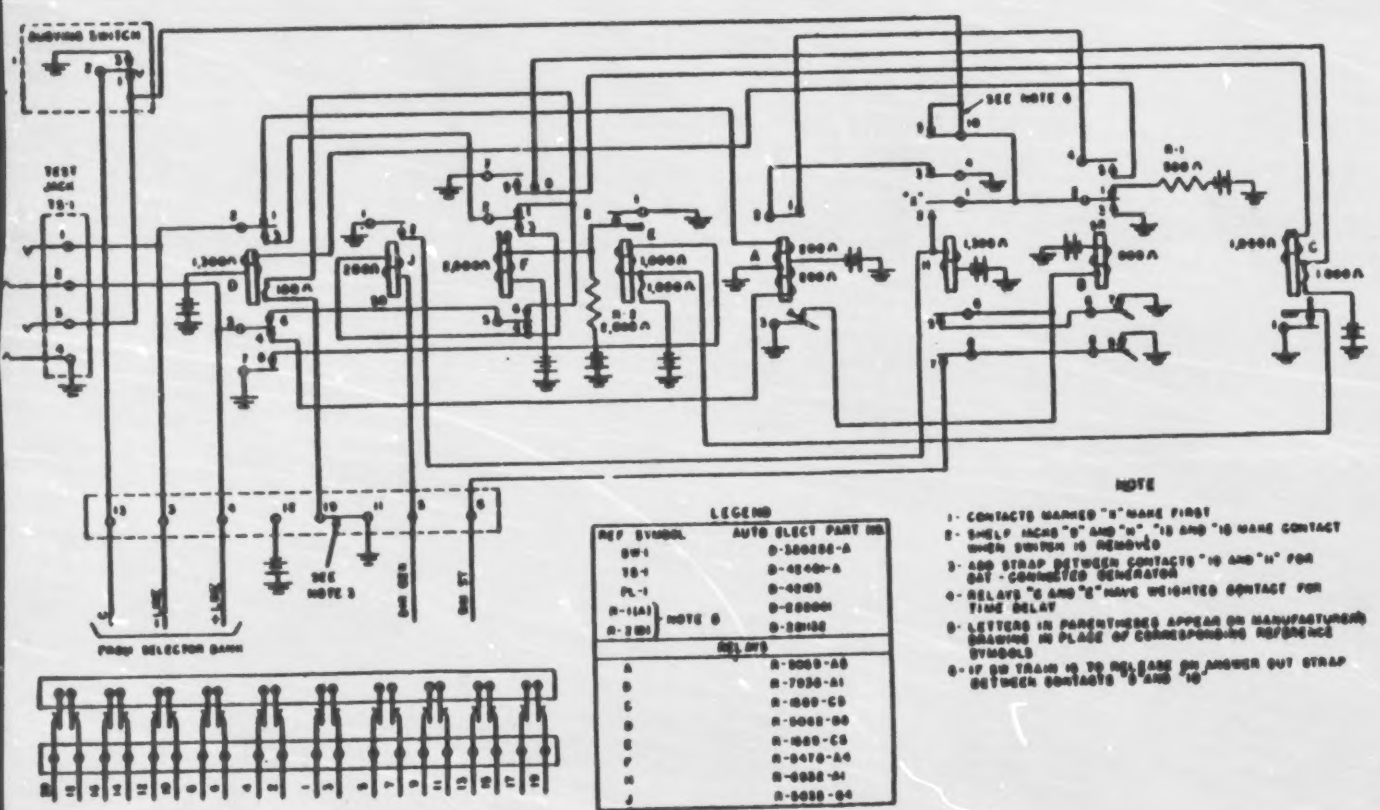
Foldout 5. Schematic diagram of step-by-step generator control and circuit of transfer relays.



Foldout 6. Schematic diagram of step-by-step fire repeater circuit.



Foldout 7. Schematic diagram of step-by-step pulse repeater circuit.



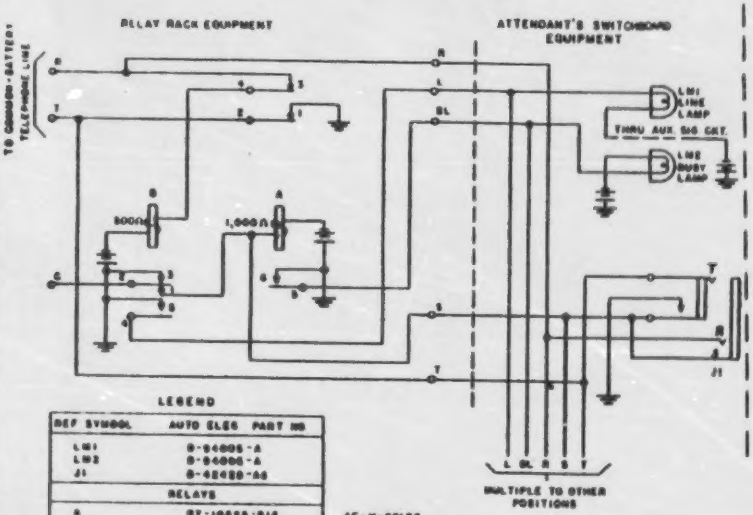
LEGEND

REF SYMBOL	AUTO ELECT PART NO.
SW-1	D-380256-A
TS-1	D-45401-A
PL-1	D-40103
R-1(A) } NOTE 5	D-280001
R-2(B)	D-28106
RELAYS	
A	R-9060-A8
B	R-7036-A1
C	R-1000-C8
D	R-9062-B6
E	R-1000-C8
F	R-8470-A4
H	R-9062-A1
J	R-9038-B4

NOTE

1- CONTACTS MARKED "X" MAKE FIRST
2- SHELF JACKS "5" AND "6", "13 AND "10 MAKE CONTACT WHEN SWITCH IS REMOVED
3- ADD STRAP BETWEEN CONTACTS "19 AND "11" FOR BAT-CONNECTED GENERATOR
4- RELAYS "C AND "E" HAVE WEIGHTED CONTACT FOR TIME DELAY
5- LETTERS IN PARENTHESES APPEAR ON MANUFACTURER'S DRAWING IN PLACE OF CORRESPONDING REFERENCE SYMBOLS
6- IF SW TRAIN IS TO RELEASE ON ANSWER CUT STRAP BETWEEN CONTACTS "9 AND "10"

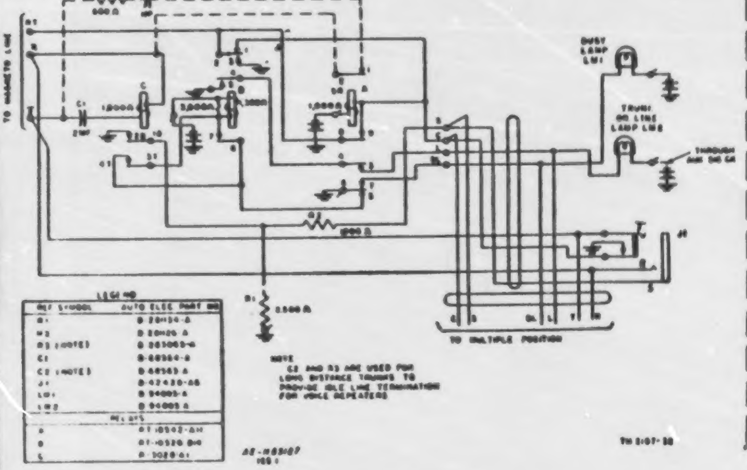
Foldout 8. Schematic diagram of step-by-step reverting call switch circuit.



LEGEND

REF SYMBOL	AUTO ELEC PART NO
LM1	B-84005-A
LM2	B-84006-A
J1	B-42420-A6
RELAYS	
A	RT-10525-816
B	RT-10604-817

Figure 1 *Common battery line circuit,*



LEGEND

REF SYMBOL	AUTO ELEC PART NO
R1	B-20134-A
R2	B-20126-A
R3 (NOTE)	B-263063-A
C1	B-68364-A
C2 (NOTE)	B-68363-A
J1	B-42430-A6
LM1	B-94005-A
LM2	B-94005-A
RELAYS	
A	RT-10242-AH
B	RT-10520-BH
C	R-1020-A1

Figure 3 *Magneto or ring-down trunk circuit.*

a

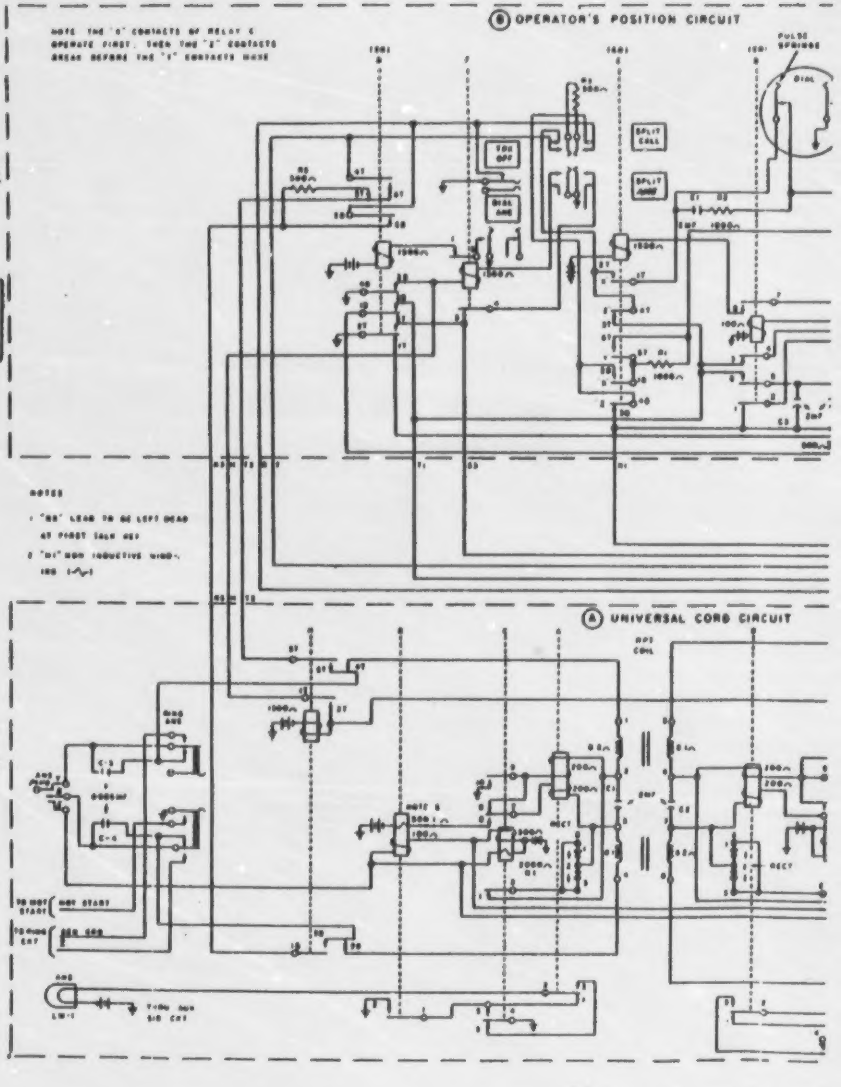
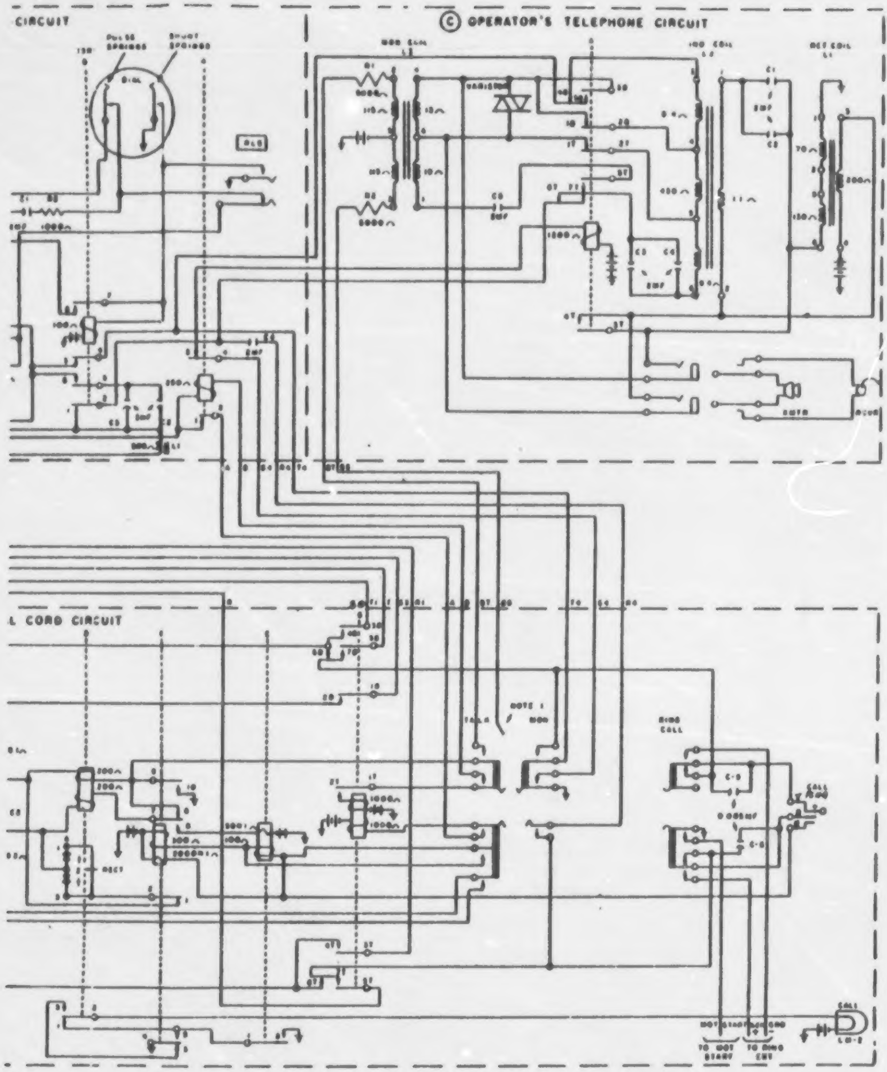

NOTE THE "X" CONTACTS OF RELAY C OPERATE FIRST, THEN THE "Z" CONTACTS BREAK BEFORE THE "Y" CONTACTS MOVE
Ⓑ OPERATOR'S POSITION CIRCUIT
PULSE SPRINGS
DIAL
SPLIT CALL
SPLIT ANS
NOTES
1 "RR" LEAD TO BE LEFT DEAD AT FIRST TALK KEY
2 "D1" NON INDUCTIVE WINDING
Ⓐ UNIVERSAL CORD CIRCUIT
RPT COIL
TO HOLD START
TO RING CKT
THRU AUX SIG CKT

Figure 2 *Universal Cord Circuit an*

b

Foldout 9a.

a



Universal Cord Circuit and Associated Equipment.

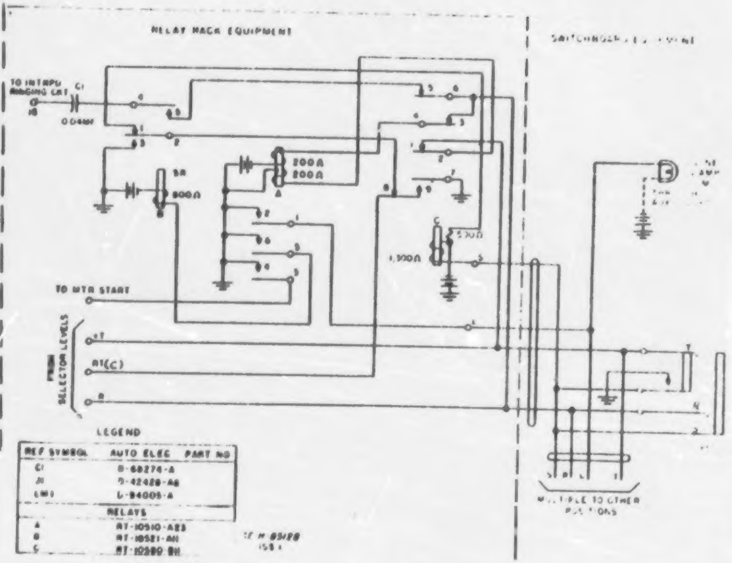


Figure 4 *Trunk circuit from selector level 0 (information)*

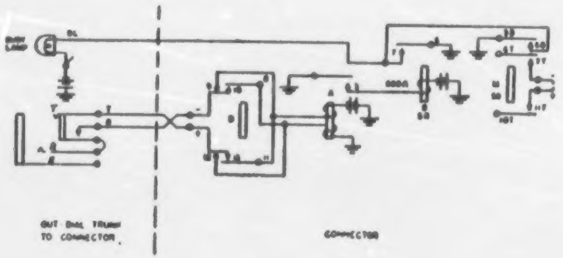
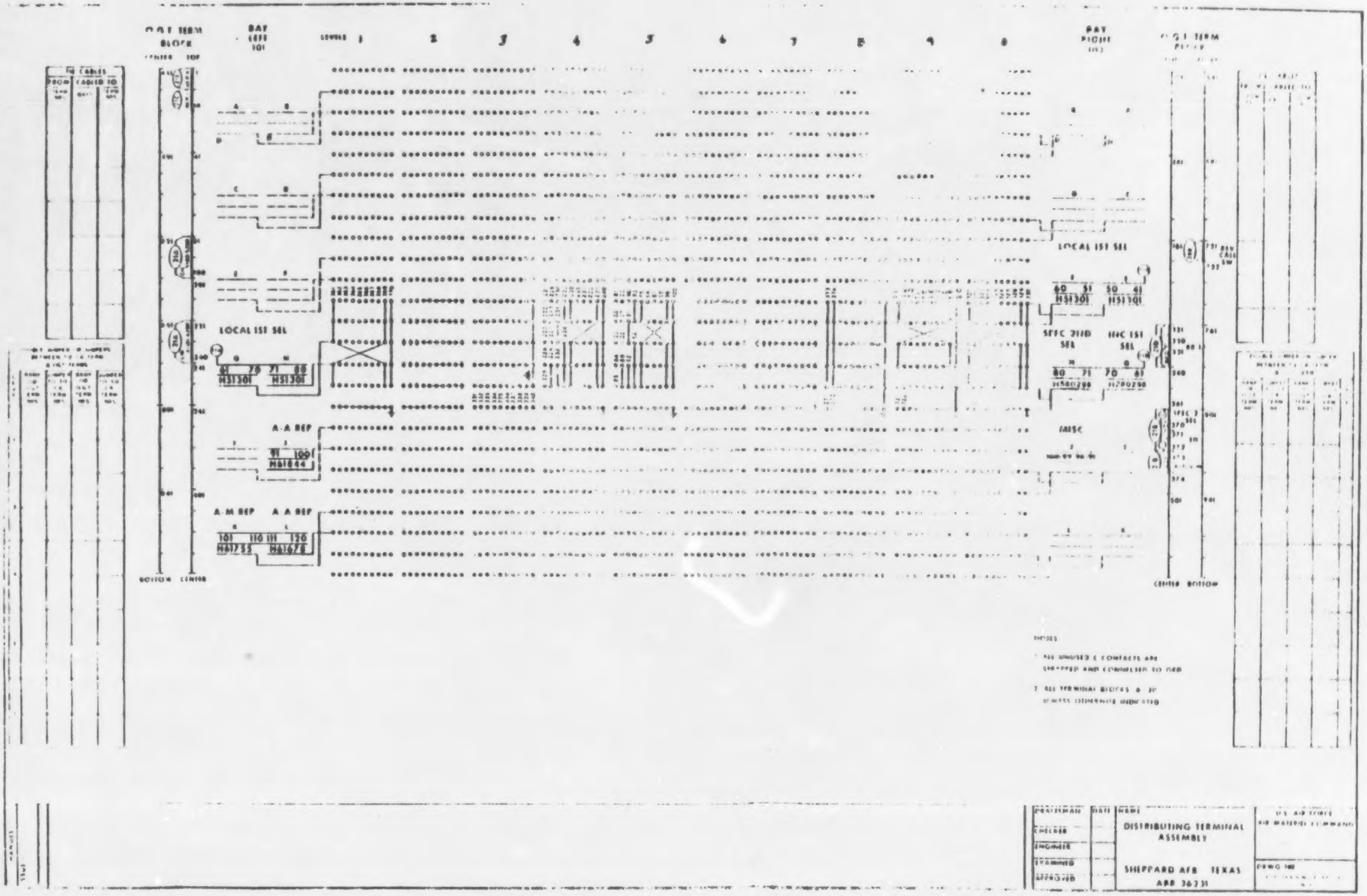


Figure 5 Out-Dial-to-Connector Trunk

Foldout 9b. Schematic diagrams of step-by-step attendant's cabinet and associated circuits.

b



Foldout 10. Distributing terminal assembly (DTA) drawing

STOP-

1. **MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.**
2. **USE NUMBER 2 PENCIL ONLY.**

36251 03 23

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE
STROWGER STEP-BY-STEP TELEPHONE SYSTEM

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DONT'S:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (400) A control device for a step-by-step linefinder is the

   a. CB relay.
   b. selector.
   c. connector.
   d. distributor.

2. (400) The operated step-by-step system device which starts the linefinder searching for a marked line is the

   a. RT relay.
   b. SW relay.
   c. G3 relay.
   d. line relay.

3. (400) Which one of the following functions is provided by the Strowger telephone system distributor?

   a. Direct control of all linefinders in the system.
   b. Direct control of one group of linefinders in a system.
   c. Connects 150 linefinders to its 25 horizontal banks with double-ended wipers.
   d. Stores dial pulses then sequentially releases them at timed interval to the succeeding equipment.

4. (400) Which of the following relays are included in the Strowger group relays?

   a. YD, PU, and AS.
   b. A, B, E, F, and G.
   c. A3, B3, C3, H3, and P3.
   d. SW, XD, HA, RT, and AB.

5. (400) Which one of the following group relays is a pulsing relay?

   a. A3.
   b. B3.
   c. H3.
   d. P3.

6. (400) Preferential hunting by linefinders limits the over use of certain equipment and

   a. reduces hunting time.
   b. expands searching actions.
   c. eliminates wiper searching on all bank levels.
   d. increases in use time of linefinders by improved wiper condition due to continuous wiping action.

7. (401) The distributor level at the far right on foldout 1 is the

   a. guard level.
   b. finder start level.
   c. vertical stepping level.
   d. lower bank cut-through level.

8. (402) Which one of the following relays provides timing control for the step-by-step linefinders?

   a. E3, releasing relay N3.
   b. A3, through its sequence of actions.
   c. B3, through its sequence of actions.
   d. P3, by stopping the vertical stepping.

9. (402) The step-by-step relay contacts that complete the operating circuit for the linefinder vertical magnet are (see FO 1)

   a. 4 and 5 of relay D3.
   b. 10 and 11 of relay B.
   c. 1 and 3 of relay A3.
   d. 2 and 3 of relay K3.

10. (403) The step-by-step linefinder steps vertically when

    a. relay A3 and the vertical magnet operate in opposition.
    b. relay A3 and the vertical magnet operate in conjunction.
    c. relays L and A3 and the vertical magnet pulse alternately.
    d. relays L and A3 and the vertical magnet pulse simultaneously.

11. (403) Which of the following Strowger system devices keeps the distributor searching the linefinders?

    a. Motor magnet.
    b. Rotary magnet.
    c. Vertical magnet.
    d. All of the above.

12. (403) Which of the following sets of Strowger equipment relays are held operated for the duration of a call?

    a. Relays D and L.
    b. Relays E3 and H3.
    c. Relays A, B, D, and L.
    d. Relays A3, B3, D3, and F3.

13. (404) Which one of the following conditions holds the Strowger equipment operated during a telephone call?

    a. Ground on the C lead.
    b. Ground on the + lead.
    c. Negative battery on the C lead.
    d. Negative battery on the - lead.

14. (404) What indicator identifies for you that a Strowger linefinder has not released?

    a. Red release lamp.
    b. Green release lamp.
    c. Green aisle pilot lamp.
    d. Red flag above blown fuse.

15. (404) What Strowger relay must have operated and restored if the second group of linefinders is searching above the fifth bank level of contacts?

    a. Relay A.
    b. Relay D.
    c. Relay L.
    d. Relay P3.

16. (404) Which Strowger equipment lead has the potential which makes the calling telephone busy to another incoming call?

    a. +.
    b. -.
    c. CN.
    d. Guard.

17. (405) Having seen the Strowger linefinder RLS lamp glowing and checked the linefinder, but found it released, which one of the following contact sets would be defective (see FO 1)?

    a. 1 and 2 of C3 are dirty.
    b. 1 and 2 of G3 are dirty.
    c. 1 and 2 of G3 are maladjusted (bent to make).
    d. 1 and 2 of C3 are maladjusted (separated too much).

18. (405) Which set of contacts, if defective, would prevent a traffic count (see FO 1)?

    a. 3 and 4 of SW-6.
    b. 3 and 4 of SW-7.
    c. 3 and 4 of relay C3.
    d. 3 and 4 of relay G3.

19. (405) Having operated the busying switch SW-6 and found ground on the ATB GRND lead, which set of contacts could be at fault?

    a. 3 and 4 of E3.
    b. 3 and 4 of SW-7.
    c. 1 and 2 of SW-1.
    d. 1 and 2 of SW-6.

20. (406) Which of the following wiring patterns applies to the step-by-step system?

    a. Line circuit terminals are jumpered to selector switch wipers.
    b. Linefinder terminals are wired to selector shelf jack contacts.
    c. Shelf jack of linefinders are connected to selector shelf jacks.
    d. Line circuit terminals are multiplied with linefinder switch wipers.

21. (406) The purpose of relay A in the Strowger selector is to

    a. pulse with the dial.
    b. hold line circuit L relay operated.
    c. cut linefinder through to connector.
    d. select between upper and lower contact banks.

22. (406) Cross-connecting selector terminals is done at the

    a. DTA.
    b. main frame.
    c. selector rotary switch.
    d. rotary switch linefinder.

23. (407) Which set of listed contacts is in the dial tone circuit for the Strowger selector circuit (see FO 2)?

    a. 3 and 4 of SW-1.
    b. 4B and 5B of relay F.
    c. 1T and 2T of relay F.
    d. 2B and 3B of relay F.

24. (407) Step-by-step line circuit relay L is kept operated by (see FO 2)

    a. negative 48 volts.
    b. ground on the C lead.
    c. ground on the selector C wiper.
    d. ground from contact 5T of relay F.

25. (408) Which one of the following results first when the Strowger selector VON switch operates (see FO 2)?

    a. Relay E operates.
    b. Relay F operates.
    c. Relay B releases.
    d. Relay B holding circuit is closed.

26. (408) In a Strowger system, the dialed digit 0 operates

    a. selector relay A once.
    b. selector relay B ten times.
    c. and releases selector relay A ten times.
    d. and releases selector relay B ten times.

27. (409) Which one of the following actions operates the step-by-step selector rotary magnet (see FO 2)?

    a. Relay C releases.
    b. Relay E releases.
    c. VON switch releases.
    d. Relay A in connector is seized.

28. (410) Using FO 2, when the selector has cut-through and relays A and B have restored, operated relay F

    a. is the next relay to restore.
    b. permits the release magnet to operate.
    c. is connected in series with the rotary magnet.
    d. transfers impulses from the vertical magnet to the rotary magnet.

29. (411) Which Strowger relays restore following replacement of the calling telephone handset (see FOs 2 & 3)?

    a. Relays A, B, and F in selector.
    b. Relays A, B, E, and F in selector.
    c. Relays A and B in connector and F in selector.
    d. Relays A, B, and F in selector and A and B in the connector.

30. (412) The ATB tone circuit for the Strowger system calling telephone includes contacts (see FO 2)

    a. 4 and 5 of SW-3, 1B and 2B and 4B and 5B of relay F.
    b. 3 and 5 of SW-3, 1B and 2B and 4B and 5B of relay F.
    c. 3 and 5 of SW-3, 2B and 3B and 5B and 6B of relay F.
    d. 4 and 5 of SW-3, 2B and 3B and 5B and 6B of relay F.

31. (413) What action is responsible, during the release of the selector (FO 2) from ATB, for the operation of the vertical magnet?

    a. The release of relay A.
    b. The release of relay E.
    c. The operation of relay B.
    d. The operation of relay C.

32. (414) What is the trouble when a step-by-step selector (FO 2) fails to step rotary?

    a. The E relay does not release.
    b. Contacts 2 and 3 of relay C are dirty.
    c. Contacts 3 and 4 of relay E are worn.
    d. The rotary interrupter springs fail to open.

33. (414) Why does the F relay in the selector (FO 2) operate and then release after cut-through?

    a. Relay E fails to release.
    b. Relay B fails to release.
    c. Contacts 2T and 3T of the F relay are dirty.
    d. Contacts 4B and 5B of the F relay are dirty.

34. (415) When a step-by-step system serves over 200 lines, three important functions of its regular connector are: to ring the called telephone, furnish

    a. ringback tone, and cut off dial tone.
    b. talking battery, and hold the switch train operated.
    c. ATB tone, and provide talking battery to the called line.
    d. dial tone, and provide talking battery to the calling line.

35. (415) Which of the following is a correct statement about step-by-step test connector equipment?

    a. Switches the ringing current generator "ON."
    b. Mounted at the center of the connector shelf.
    c. Automatically supplies dial tone and busy tone.
    d. Used with the test distributor for line testing.

36. (416) When relay A is operated in the step-by-step connector circuit, the operating circuit of relay

    a. C is closed and relay F is released.
    b. D is closed, but relay G is released.
    c. B is opened, but the C lead is grounded.
    d. B is closed and the circuit of the release magnet is open.

37. (416) A step-by-step connector is seized and holding ground is connected to the C lead (FO 3) by relay

a. A.
b. B.
c. C.
d. E.

38. (417) The step-by-step vertical magnet of a connector switch operates when relay A

a. is operated and relay B is released.
b. is released and relay B is operated.
c. and relay B are restored.
d. and relay B are operated.

39. (417) When relay C is unoperated in a step-by-step connector circuit, the pulsing circuit is transferred from the

a. rotary magnet to the release magnet in series with relay E.
b. release magnet to the rotary magnet in series with relay E.
c. vertical magnet to the rotary magnet in parallel with relay E.
d. vertical magnet to the release magnet in parallel with relay E.

40. (418) The rotary magnet of a step-by-step connector operates each time relay

a. A restores.
b. E restores.
c. A operates.
d. C operates.

41. (418) The step-by-step connector switch wipers (FO 3) rotate because

a. relay A operates while the dial pulse springs are open.
b. relay B operates and then restores permitting the rotary magnet to operate.
c. relay A restores while the dial pulse springs are open and then reoperates when the pulse springs close.
d. the rotary magnet restores while the dial pulse springs are open and operates at the end of each dial pulse.

42. (419) In a step-by-step system, ringing current to the called line (FO 3) is cut off by

a. the release of the group relay S.
b. the operation of selector relay F.
c. the operation of connector relay F.
d. lifting the receiver to start the ringing current interrupter.

43. (419) In a step-by-step system, talking battery is supplied to the calling line through

a. relay B in the connector circuit.
b. contacts of relay B in the connector circuit.
c. the 200-ohm winding of relay A in the connector circuit.
d. the 200-ohm winding of relay D in the connector circuit.

44. (420) Which relay in a step-by-step connector (FO 3) releases first when the called party hangs up first?

a. A.
b. B.
c. D.
d. F.

45. (420) Which relay in a step-by-step connector (FO 3) remains operated after only one of the parties hangs up?

a. A.
b. B.
c. D.
d. F.

46. (421) In a step-by-step connector circuit, the contacts of which operated relay connect busy tone to the calling line?

a. H.
b. G.
c. F.
d. E.

47. (422) If contacts 4 and 5 of operated relay F in a step-by-step connector circuit fail to make contact, the

a. talking circuit would be incomplete.
b. called telephone would continue to ring.
c. calling subscriber would not hear a ringback tone.
d. called subscriber would hear a buzzing in his receiver.

48. (423) What are the ampere ratings of indicator alarm fuses used in Strowger central offices?

a. 1, 2, and 3.
b. 1, 3, and 5.
c. 2, 3, and 4.
d. 3, 4, and 5.

49. (423) Signal group relay C1 is designated as

a. GRD.
b. FUSE.
c. RLS PU.
d. RLS ALM.

50. (424) The hold path for B6 during time 1 is through alarm and supervisory circuit (FO 4) contacts

a. 5 and 7 of B6.
b. 2 and 3 of B7.
c. 1 and 2 of B7.
d. 7 and 6 of B6.

51. (424) B6 relay receives its first operating path through alarm and supervisory circuit (FO 4) contacts.

a. 3 and 2 of B7.
b. 5 and 7 of B6.
c. 6 and 7 of B6.
d. 1 and 2 of B7.

52. (425) The major alarm bell does not ring under any condition, the most probable trouble is

a. relay C38 does not operate.
b. relay C33 does not operate.
c. open 4 and 5 contacts of relay C38.
d. upper contacts of major AL CO key open.

53. (426) To float charge the central office battery, the output of the charges is regulated within the limits of

a. .5 percent.
b. 1 percent.
c. 1.5 percent.
d. 2 percent.

54. (426) What is the output of the central office dynamotor (ringing machine)?

a. 19 volts, 80 hertz.
b. 90 volts, 25 cycles.
c. 25 volts, 90 cycles.
d. 80 volts, 19 hertz.

55. (427) When relay D24 operates, it closes an operate path to relay (see FO 5)

a. D26.
b. D27.
c. D28.
d. all of the above.

56. (427) Relay D5 operates from (see FO 5)

a. ground from generator control 1 lead.
b. ground from generator control 2 lead.
c. battery from generator control 1 lead.
d. battery from generator control 2 lead.

57. (428) If there is no busy tone to the connector bays from either machine, the most probable cause would be (see FO 5)

a. open BT1 coil.
b. windings of D26 shorted.
c. contacts on cam 6 shorted.
d. contacts 1T/2T of D26 dirty.

58. (428) What is the trouble when water has to be added to the central office battery monthly?

a. The battery needs to be replaced.
b. The EQUALIZE switch needs to be operated.
c. The float level adjustment needs to be increased.
d. The float level adjustment needs to be decreased.

59. (429) The fire reporting number for military bases usually has

a. 1711 as its terminating digits.
b. 7 as its units digit and 1 as its tens digit.
c. 1 as its units digit and 7 as its tens digit.
d. 17 as its preliminary digits and 22 as the terminating digits.

60. (429) The pulse repeater repeats the dial pulses by

a. amplifying the pulse signal.
b. reducing the trunk impedance.
c. reducing the trunk resistance.
d. reducing the electrical distance that the pulse travels.

61. (429) The reverting call switch is accessed from the banks of the

a. test selector.
b. first selector.
c. second selector.
d. special second selector.

62. (430) The operator. in a Strowger exchange may reach any telephone served by the office through the use of

a. auto-to-auto trunks and auto-to-manual trunks.
b. out-dial-to-line equipment and auto-to-auto trunks.
c. auto-to-auto trunks and out-dial-to-connector trunks.
d. out-dial-to-line equipment and out-dial-to-connector trunks.

63. (430) How many cord circuits are there on one position of an Automatic Electric switchboard?

a. 18.
b. 17.
c. 16.
d. 15.

64. (431) When the fire department answers a step-by-step system fire repeater call, the loop circuit is completed through the windings of fire repeater relay

a. E lighting lamp LM1.
b. E and lights lamp LM2.
c. C extinguishing lamp LM1.
d. F which extinguishes lamp LM2.

65. (431) When the calling subscriber disconnects after a fire call, the

a. A relay is first to restore.
b. D relay is first to restore.
c. E relay releases and opens the circuit to relay A.
d. F relay releases and opens the circuit to relay E.

66. (432) When a step-by-step system pulse repeater (FO 7) is seized by the outgoing selector, the sequence of relay operation is

a. A-B-E-F.
b. A-B-F-D.
c. A-B-F-E.
d. A-B-C-F.

67. (433) After the reverting call switch (FO 8) has been seized and the installer hangs up, the A relay releases and operates the

a. B relay.
b. D relay.
c. E relay.
d. F relay.

68. (433) What type of relay is the E relay in the reverting call switch (FO 8)?

a. Timing.
b. Tuning.
c. Slow-acting.
d. Slow-to-release.

69. (434) The operate path for relay B in the selector level 0 trunk (FO 9) passes through contacts

a. 1 and 2 of relay A.
b. 3 and 4 of relay A.
c. 5 and 6 of relay A.
d. 8 and 9 of relay C.

70. (434) What relay and contacts complete the pulsing path through the operator's position circuit (FO 9)?

a. 1 and 2 of relay A.
b. 4 and 6 of relay D.
c. 6 and 6 and 7 and 8 of relay A.
d. 1T and 2T and 1B and 2B of relay C.

71. (435) If contacts 10/12 of the F relay in the fire repeater circuit (FO 6) do not make, there is

a. no ringing of the fire alarm.
b. no operating path for the C relay.
c. no operating path for the F relay.
d. continuous ringing of the fire alarm.

72. (435) The reverting call switch (FO 8) will only send ring current out on the tip side of the line. What would be the probable trouble?

a. 7 and 8 of the D relay dirty.
b. 7 and 9 of the F relay dirty.
c. 8 and 9 of the B relay dirty.
d. 1 and 2 of the J relay dirty.

73. (435) In the pulse repeater circuit (FO 7), what would cause the calling subscriber to drop back to dial tone everytime he accessed the trunk?

a. Contacts 2 and 3 of A open.
b. Contacts 6 and 7 of E open.
c. Contacts 1 and 3 of C open.
d. Contacts 1 and 2 of B shorted.

74. (436) Depression of the stepping switch test set loop switch causes which of the following circuit changes?

a. The current decreases.
b. The resistance decreases.
c. A decrease in voltage and current.
d. An increase in voltage and current.

75. (436) After testing a faulty ring trip problem connector switch with a test handset, and not finding any trouble, what should you do next?

a. Wait for another trouble report.
b. Test the connector using the varying machine.
c. Test the connector using the type 26A switch tester.
d. Remove the switch from the shelf and current flow the ring trip relay.

76. (437) The reverting call switch is accessed from the banks of a

a. test selector.
b. first selector.
c. second selector.
d. special second selector.

77. (437) What type of multiple is shown in foldout 10 for outgoing trunks 1 through 10?

a. Graded.
b. Series.
c. Parallel.
d. Straight.

78. (438) If a call is to be traced either forward of backward, you could start by

a. checking the bay cord.
b. reading the DTA drawing.
c. determining the wiper position.
d. determining the calling party's number at the linefinder.

79. (438) What single relay, operated, in the connector indicates that the number it is stepped to is in the upper bank?

a. F.
b. H.
c. J.
d. K.

80. (438) When determining the hundreds digit at the linefinder, you short test jacks 3 and 4 of the linefinder causing the

a. upper bank lamp to light, indicating that the number is in the upper bank.
b. upper bank lamp to light, indicating that the number is in the lower bank.
c. lower bank lamp to light, indicating that the number is in the upper bank.
d. lower bank lamp to light, indicating that the number is in the lower bank.

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TELEPHONE SWITCHING EQUIPMENT REPAIRMAN (ELECTROMECHANICAL)

(AFSC 36251)

Volume 4

XY Telephone System

Extension Course Institute

Air University

Preface

IN THIS VOLUME you are introduced to the XY telephone system in almost the identical way you were introduced to the Strowger system in Volume 3 of this course.

The schematic diagrams used for displaying the relationships of the various circuits of a switching system are the combinations of simple direct-current circuits which are opened and closed in proper sequence by the operation of relays and switches. The symbols used in the sketches and the schematics will vary somewhat with the different types of equipment. Although some of the symbols have not been standardized, all will be easily recognized on the different schematics used. There are 14 schematic foldouts included with this volume. They are printed and bound as a separate inclosure.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to SAAS/TTOXU, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

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This volume is valued at 24 hours (8 points).

Material in this volume is technically accurate, adequate, and current as of December 1978.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objective gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

Linefinder Equipment

LIFTING a telephone handset operates relays to complete circuits within a telephone switching center. Since we already know that the LINE relay is the first unit to operate in any switching center when a call is initiated, we need to begin this chapter with a discussion of this relay in relation to XY linefinder circuits. You must understand the operation and interrelationship of these line and linefinder circuits, as well as the circuits in the XY switching equipment, as a basis for your future maintenance activities. We will include in this discussion the linefinder allotter circuits which control the connecting of a line with a linefinder.

You will remember from your study of Volume 2 of this course that XY Universal switch steps in a horizontal plane; first to the right and then, into the wire banks. The S (sleeve) wiper in the XY system is the same wiper as the C wiper in the Strowger. The HS (helping sleeve) wiper is the same wiper as the EC wiper, and the X and XX wipers serve the same basic functions as the vertical wiper and normal post springs in the Strowger system.

1-1. Linefinder Description

The switching equipment in an XY central office is available to all of the individual stations served by the exchange. Consequently, each unit of the switching equipment is shared, at any moment, by several stations. The line provides a means of connecting and releasing the stations from the shared equipment. When connected to a calling station, the line circuit extends the transmission lines from the telephone station to the shared equipment. When connected to a called station, the line circuit disconnects the line relay from the shared equipment.

600. Using figure 1-1 as necessary, name the three leads between the XY line circuit and the connector banks and determine the number of linefinders and SY line circuits needed to support an organization.

Line Equipment and Circuits. In a 100-line group there are 14 linefinders, 2 allotters, and 100 line circuits. The 100 line circuits are mounted on the first 10 linefinder plates. Thus, the line circuits are mounted with 10 line circuits and one linefinder circuit per plate, except for the bottom four circuit plates. They have only linefinders. The linefinder circuit plates are mounted horizontally, one below the other, on the linefinder shelf; each linefinder circuit plate is therefore on a horizontal plane with its XY switch.

In all XY systems the line circuit consists of a dual relay (C-type): the line relay LR and the cutoff relay CO. A schematic diagram of the line circuit we will be studying is shown in figure 1-1. You can see in this figure that the line circuit has two terminals connected to the line (terminal 1 of shelf plug C is connected to tip, and terminal 6 of the plug is connected to ring). Also, the circuit has three connections to the connector banks and four connections to the linefinder banks. Of course, two of the connections for each are in multiple.

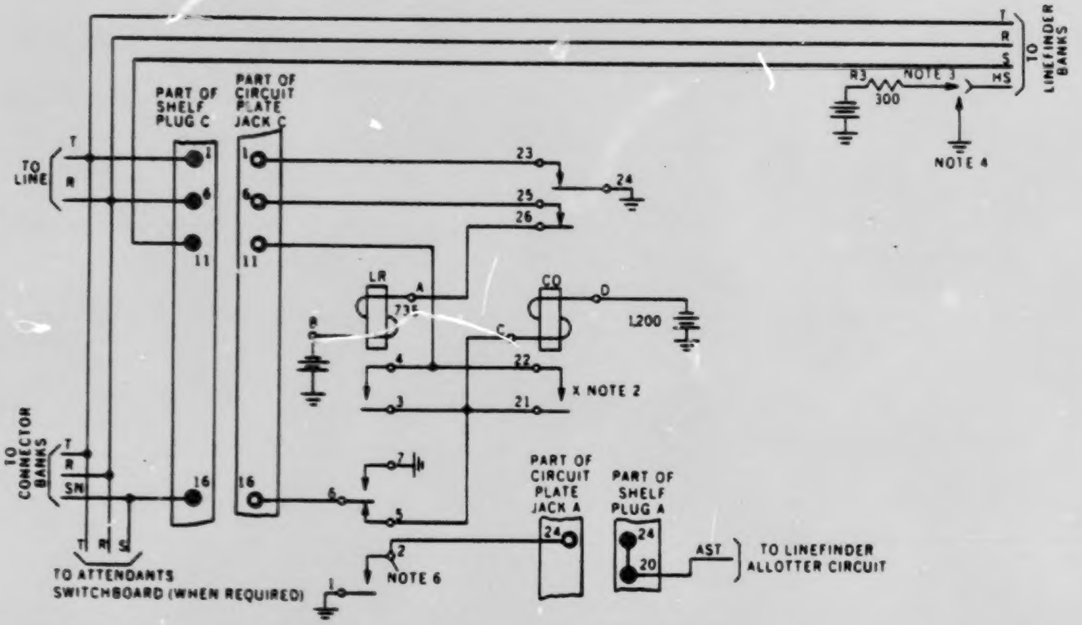
The linefinder circuit is used to find the lines in the linefinder switch bank to which the line circuit is connected and to extend the line through to the succeeding switching equipment (selector or connector).

Exercises (600):

1. Approximately how many linefinders should be installed in a 2000-line XY switching center?

2. How many XY line circuits will you be responsible for if the organization to which you are assigned serves 3000 lines?

3. Name the three leads between the XY line circuit and the connector banks.



NOTES 1 RESISTANCES ARE IN OHMS
2 X CONTACTS OPERATE FIRST
3 CONNECT HS LEAD TO RESISTOR R3 FOR EXECUTIVE RIGHT-OF-WAY SERVICE
4 CONNECT HS LEAD TO GROUND FOR RESTRICTED SERVICE LEVEL
5 CIRCUIT NO 1 SHOWN WIRED
6 AST LEAD IS COMMON TO 10 LINE CIRCUTS

Figure 1-1. XY system line circuit.

601. Concerning operating features of the XY linefinder-allotter circuit, identify the XY allotter circuits, the rows of bank terminals for the XY linefinder banks, and the consequences when two faulty linefinders are discovered successively by allotter A, and name the magnets for the XY switch. Consult foldout 1 as required.

Linefinder-Allotter. Foldout 1, found in a separate inclosure accompanying this volume, shows the two allotters for the system. Notice that each allotter has ten relays. One allotter serves the even-numbered levels of the switchbank, while the other serves the odd-numbered levels. Each allotter determines which linefinder XY switch will search for the marked lines of the line switch in the switchbank. It also preselects a particular linefinder circuit for linefinding operation and selects each linefinder circuit in such a way that the workload is distributed evenly among all of the linefinders in a particular shelf. Another function of the allotter is to control the stepping of the linefinder switch as it searches for the marked line. The allotter is equipped to provide emergency operations in the case the allotter or a linefinder fails. If the allotter encounters a defective linefinder circuit, it automatically detaches from the faulty linefinder circuit and steps to a succeeding idle linefinder. If an allotter encounters two faulty linefinder circuits in succession, it automatically transfers all of its switching operations to the other allotter. The other allotter then serves all calls. If either allotter fails because of electrical or mechanical defects, all operations are transferred from the defective allotter to the other allotter.

Foldout 1 also shows you the linefinder equipment. For example, the XY and rotary switches and the linefinder banks are shown. The linefinder circuit and the allotter circuit function as a single circuit during the linefinding operation. After the linefinding operation is completed, the allotter circuit releases from the busy linefinder circuit and automatically connects to the next idle linefinder circuit.

Exercises (601):

1. List five relays in the XY allotter circuits.

2. What results when, in searching the linefinders, allotter A finds two faulty linefinders in succession?

3. Name the magnets for the XY switch.

4. Identify four rows of bank terminals for the XY linefinder banks.

1-2. Linefinder Circuit Operation

Since each linefinder switch bank connects to 100 stations, a method was provided for the linefinder to locate the station desiring service. This was done by having the line circuit mark the level in which the calling station appears.

602. Using foldout 1's XY linefinder diagram and selected textual information, identify the specific equipment or connections that indicate, in typical situations, that a telephone line is marked.

Marking a Line. The line circuit marks the level by connecting ground to the X-XX bank. The operated line circuit also places a starting ground on the allotter start (AST) lead, which starts the linefinder searching for the calling station.

Level marking. Each group of 10 lines is connected to a common AST lead, as shown in foldout 1. Lines 11 to 10, for example, are connected to one common AST lead; lines 21 to 20 are connected to another AST lead, etc. Each of the 10 AST leads is then connected to the X-XX bank in the following manner: The AST leads which serve the five odd-numbered levels of line circuits are connected to the *odd-numbered* levels of the linefinder X bank, the ST-A lead, and through contacts 27 and 28 of transfer relay TF in allotter B to relay SA in allotter A, as shown in foldout 1. Likewise, the five AST leads which serve the *even-numbered* levels of line circuits are connected to the even-numbered levels of the XX line linefinder bank, the ST-B lead, and through contacts 27 and 28 of relay TF in allotter A to relay SA in allotter B. As a result of this method of connection, allotter B can serve the odd-numbered levels of line circuits if allotter A should fail; and vice versa, allotter A can serve the even-numbered levels of line circuits if allotter B should fail. Thus, should either allotter fail, the other allotter will handle all line circuits. The following examples illustrate the principles used in marking the desired level in the X or XX bank; refer to foldout 1, tracing the circuits as we proceed. When both allotters are working properly, and assuming that line circuit 31 originates a call, ground is connected to the third wire bank of bank X. This is so, since this circuit is served by the AST lead that is common to lines 31-30. Assuming that line 66 originates a call, ground is connected to the sixth wire bank of the XX bank over the common AST lead serving lines 61-60.

When allotter B is *not* working and allotter A *is* working, the even-numbered level line circuits are transferred to the X bank by the contacts of the transfer relay of allotter A.

Marking position in level. At the same time that the line circuit grounds an X or XX bank wire, it also marks the proper position of the calling station in the selected level by connecting negative battery to the S bank wire in the switch bank. Since the linefinder switch hunts for battery on the S bank, this battery serves to stop the Y direction hunting action of the linefinder.

Exercises (602):

1. The handset at station 324 has been lifted. In which allotter, A or B, will the start relay operate?

2. Contacts 27 and 28 of relay TF in allotter B are placed in the normal position. What is this position—open or closed?

3. A calling party lifts the handset from the hookswitch. When this happens, what does a linefinder do?

4. The handset is lifted at telephone station 673. Identify the marked X-XX linefinder bank terminal and its potential when this occurs.

603. Identify the line circuit position and XY equipment devices operated when a specified subscriber lifts the telephone handset to originate a call and the potential maintaining line circuit relay operation during a call, as well as this potential's source, and name the XY line circuit relay remaining operated during a conversation. Use figure 1-1 as needed.

Originating a Call. To originate a call, the telephone user lifts the handset from the cradle of the telephone. This action closes the hookswitch contacts to complete the T and R loop to relay LR in the line circuit.

Relay LR operates. The circuit path for relay LR is shown in figure 1-1. When relay LR operates, its contacts perform the following functions:

a. Contacts 5-6 disconnect the dc winding of relay CO from the SN (sleeve normal) lead of the connector bank. This action prevents relay CO from operating at this time.

b. Contacts 6-7 place ground on the SN lead to mark this line busy at the connector banks.

c. Contacts 3-4 connect resistance battery through the winding of relay CO to the S lead of the linefinder to mark the calling line position on the S bank.

d. Contacts 1-2 place ground on the common AST lead to mark the X position of the calling line and start the linefinding action.

Relay CO operates. When the linefinder finds the calling line, it places ground on the S lead to operate relay CO. When relay CO operates, its contacts perform as follows:

a. Contacts 21-22 complete a holding circuit to the S lead.

b. Contacts 23-24 and 25-26 open the circuit to relay LR, thus releasing it.

Relay LR releases. When relay LR releases, its contacts function as follows:

a. Contacts 1-2 remove ground from the AST lead.

b. Contacts 6-7 remove ground from the SN lead. However, ground is still necessary on the SN lead to mark this line circuit busy.

c. Contacts 5-6 complete the circuit from the grounded S lead to the SN lead.

Line circuit operated. The line circuit remains operated for the length of the call. When the call is completed, all of the XY switches involved in the switch train are restored to normal and ground is removed, allowing the line circuit to restore to its normal condition. Removal of ground from the SN lead allows the line circuit to receive incoming calls.

Exercises (603):

1. Give the line circuit position and the XY equipment devices that operate when the subscriber at station 48 lifts the telephone handset.

2. Name the XY line circuit relay that remains operated during the conversation.

3. Identify the potential which keeps the line circuit relay operated during the call and where this potential comes from.

604. Concerning XY relay connections and operations that terminate a call and provide restricted service, state the method for releasing the XY line circuit relay when a called subscriber replaces the handset on the telephone and the required action to restrict a telephone station's access to a specific level in the system.

Call Termination Sequence and Restricted Service. You have already seen that, when the line circuit is connected to the linefinder, the line relay is disconnected from the transmission leads. This is done when the linefinder connects ground to the S lead at the linefinder bank, which operates the CO relay of the calling line circuit. The operated CO relay contacts 23-24 and 25-26 open the circuit of relay LR. This action disconnects everything from the T and R leads.

Line circuit operated and released. Relay CO in the terminating line circuit remains operated for the length of the call. When the call is completed, the connector restores to normal and removes ground from the SN lead. This action opens the operating circuit of relay CO; so it restores. Thus, the line circuit is returned to its normal (idle) condition.

Line circuit, restricted service. Restricted service level markings are sometimes provided to prevent certain stations from having access to certain levels in the system. When a restricted station dials a restricted level, a busy tone is returned. The restricted service line circuit is the same as that shown in figure 1-1, except that ground is connected to the HS lead. Ground on the HS lead acts along with the succeeding equipment to provide the sequence of switching operations necessary for restricted service. This will be covered in more detail in Chapter 2.

Exercises (604):

1. Name the method by which the XY line circuit relay is released when the called subscriber replaces the handset on the telephone.

2. What must you do when you are asked to restrict a telephone station from access to a specific level in the system?

605. Using figure 1-2 and foldout 1's XY linefinder diagram, name the equipment and list the actions that allocate linefinders when conditions are normal.

Allotting Linefinder Circuits. For this explanation, assume that line 75 is the originating station. Use figure 1-2 while also referring to foldout 1 and reading this manuscript.

Line 75 appears at the fifth contacts of the seventh level in the linefinder bank. Since this is an odd level, it is normally served by allotter A.

Relay FB operated. Relay FB (finder busy) is shown in the operated position, because it is normally operated. The only time that relay FB restores is when all of the linefinder circuits common to allotter A or allotter B are busy or when a fuse blows in either allotter.

The ATB lead is multiplied to each linefinder circuit. As long as one or more linefinder circuits are idle, ground is present on the ATB lead. When all grounds are removed from the ATB lead, relay FB releases, closing a circuit to the ATB meter and registering the ATB condition.

Seizure. When the handset of telephone number 75 is lifted from the cradle, the line circuit operates as we have explained previously. Accordingly, negative battery is placed on the S lead in position 5 of level 7 in the linefinder banks and ground applied to the seventh position of the X bank. This ground also operates relay SA (start allotter) to start the allotter.

Relay SA operates. Relay SA operates and starts the linefinder-allotter circuit. The contacts of relay SA perform the following functions:

a. Contacts 1-2 extend ground through terminals 26 of allotter A circuit plate jack A and shelf plug A to the start (ST) lead of the common supervisory circuit. This operates the timing and alarm equipment of the common supervisory circuit.

b. Contacts 3-4 extend ground from contacts 7-6 of the TST switch, through the emergency start fail lamp (EM STFAIL) and also through terminal 27 of allotter A circuit plate jack A and shelf plug A, to the common supervisory circuit. This starts a timing circuit which, when completed after a time interval, lights a red trouble lamp.

c. Contacts 5-6 prepare a circuit for relay PU (pickup). This circuit is prepared at this time to permit relay PU to operate if the linefinder being used is faulty. This situation is covered fully in a later section.

d. Contacts 9-10 prepare a locking circuit to relay SA. This circuit is necessary only if the last idle linefinder is being used.

e. Contacts 11-12 prepare a circuit to the X magnet in the linefinder switch.

f. Contacts 7-8 complete the operating circuit of relay GD.

Relay GD operates. Relay GD operates in series with the rotary switch magnet. But the rotary magnet does not operate at this time, because there is not enough current flowing through it. The operation of relay GD partially prepares and then completes the circuits given below:

a. Contacts 23-24 extend ground from terminal 14 of allotter A shelf plug A to terminal 20 of rotary switch B. This ground steps rotary switch B to another idle linefinder when both allotters are connected to the same linefinder at the same time.

b. Contacts 25-26 complete a locking circuit for relay GD. This circuit is completed at this time to allow relay GD to remain operated after relay XS (X stopping) operates. (Relay XS operates later.)

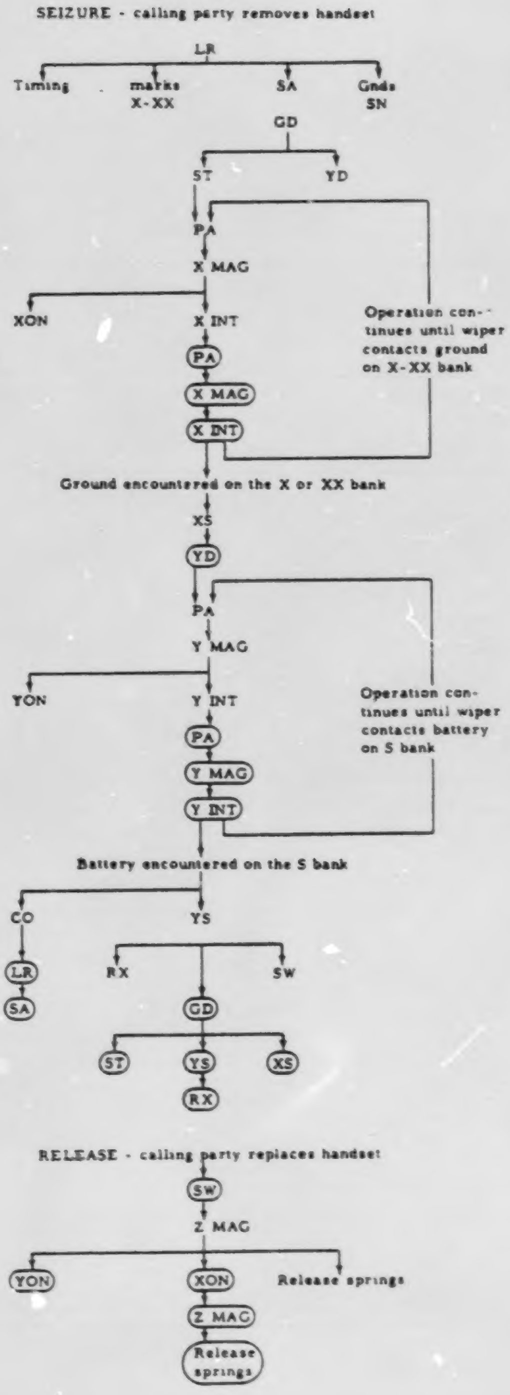

SEIZURE - calling party removes handset
LR
Timing
marks X-XX
SA
Gnds SN
GD
ST
YD
PA
X MAG
XON
X INT
Operation continues until wiper contacts ground on X-XX bank
PA
X MAG
X INT
Ground encountered on the X or XX bank
XS
YD
PA
Y MAG
YON
Y INT
Operation continues until wiper contacts battery on S bank
PA
Y MAG
Y INT
Battery encountered on the S bank
CO
YS
LR
SA
RX
SW
GD
ST
YS
XS
RX
RELEASE - calling party replaces handset
SW
Z MAG
YON
XON
Release springs
Z MAG
Release springs

Figure 1-2. Relay sequence of operation, linefinder-allotter.

c. Contacts 10-11 extend ground through terminals 1 of allotter A circuit plate jack C and shelf plug C to the wiper in level A of rotary switch A. This grounds the contact that the wiper is resting on to prevent rotary switch B from seizing the same linefinder to which rotary switch A is connected.

d. Contacts 7-8 further prepare the circuit for the X magnet in the linefinder.

e. Contacts 5-6 extend ground through the bd winding of relay XS to contact 22 of relay XS. This prepares a locking circuit for relay XS. This ground is also supplied through resistor R7 and the winding of relay YS to negative battery. Current flows through relay YS (Y stopping), but not enough current flows to allow it to operate. It is partially energized at this time to insure that it operates quickly to stop Y-direction stepping of the linefinder.

f. Contacts 3-4 prepare the operating circuit for relay XS. Relay XS will operate when the X wiper connects with ground on the marked level in the X bank (level 7 in this example).

g. Contacts 29-30 complete the locking circuit to relay SA, from negative battery through the ca winding of relay SA, contacts 30-29 of relay GD, contacts 10-9 of relay SA, to the first operating ground from the AST lead.

h. Contacts 31-32 extend the ac winding of relay YS to the S wiper of the linefinder and ground from the CO relay in the line circuit. Relays YS and CO will operate when the S wiper meets resistance negative battery in the marked position of the linefinder bank (position 5 of level 7, in this example).

i. Contacts 27-28 prepare an operating circuit for relay PA (pulse assist). This circuit is not completed until relay ST (start relay) in the linefinder operates.

j. Contacts 1-2 complete the operating circuit of relay YD (Y delay) and contacts 21-22 complete the operating circuit to relay ST in the linefinder.

Relay YD operates. Relay YD performs the following functions:

a. Contacts 6-7 prepare a circuit to operate relay PU if the linefinder fails to step in the X direction.

b. Contacts 3-4 open the prepared operating circuit of relay YS. These contacts open to keep YS relay from operating at this time.

c. Contacts 1-2 prepare a locking circuit for relay YD.

d. Contacts 26-27 prepare a circuit from ground at contact 11 of relay SA to the X magnet in the linefinder circuit.

Relay ST operates. Relay ST performs the following functions:

a. Contacts 1-2 bridge a 510-ohm resistor (R1) across the T and R leads to the succeeding equipment. This bridging circuit operates relay CB in the first numerical switch (selector or connector) to seize that switch in preparation for dialing.

b. Contacts 3-4 further open the circuit to relay RA (shelf supervisory equipment). Relay RA operates each time the release magnet of the linefinder switch operates. If the release magnet should operate and not release the switch, relay RA would stay operated and light the release lamp, which is located on the shelf supervisory circuit plate.

c. Contacts 12-13 complete a circuit to relay PA.

d. Contacts 6-7 and 9-10 partially complete the circuit path to the X magnet of the linefinder.

Relay PA operates. Relay PA operates and performs the following functions:

a. Contacts 4-5 prevent the rotary switch from stepping to the next linefinder, while the X or Y magnet is energized.

b. Contacts 2-3 complete the operating circuit of the X magnet. This starts the switch wipers stepping in the X direction.

Exercises (605):

1. Name the terminal that connects to ground, so that the FB relays in the allotters may be operated while the linefinder is not seeking a marked line.

2. List the XY allotter relays that operate during seizure of the linefinder switch.

3. Specify the devices that comprise a holding circuit for relay SA.

4. Identify the operated relays that provide the operating circuit for XY allotter relay YS.

5. Name the relays that provide the operating circuit for allotter relay YD and tell what its condition is.

6. Name the XY allotter relay that operates in conjunction with the stepping switch magnets.

606. Using foldout 1's XY diagrams and figure 1-3, identify the linefinder components that step the XY switch in the X direction.

Stepping in X Direction. The X magnet armature moves the X driving pawl, engaged in the teeth of the

X ratchet, and turns the X gear sprocket to slide the cog roller (the T, R, S, and HS wipers also slide) one step in the X direction. The X gear sprocket also moves the X-XX wipers one step in the Y direction.

The X off-normal (X-ON) springs operate as the switch wipers take the first step in the X direction. (To be used later.)

The X interrupter springs (X-IS) are opened before the X magnet completely operates. These contacts open the circuit to relay PA, thus releasing it. Relay PA opens the circuit to the X magnet when its 2-3 contacts open.

The X magnet releases and its armature starts to return to its normal (unoperated) position. However, before it reaches this position, the X-IS close and again complete the circuit to relay PA. Relay PA reoperates and again completes the circuit to the X magnet.

The X magnet reoperates, moving the wipers another step in the X direction, and again opens the circuit to relay PA. Relay PA releases and again opens the circuit to the X magnet. Also, the armature of the X magnet again starts to return to normal.

This sequence of operation continues until the X wiper comes into contact with the ground on the marked position of the X-XX bank. If ground had been present on the first contact of the X-XX bank, the switch wipers would have moved only one step in the X direction. However, in this example, ground is on position 7 of the X bank. Therefore, the switch wipers move seven steps in the X direction—to where the X wiper comes into contact with the ground. Ground on this contact operates relay XS in the allotter.

Relay XS operates. As relay XS operates, contacts 25-24 further open the circuit to relay PA, so that it will not reoperate when the X magnet releases. Relay PA releases, and its 2-3 contacts open the circuit to the X magnet. The remaining contacts of relay XS function as follows:

a. Contacts 22-23 complete a locking circuit for relay XS. This circuit puts the two windings of relay XS in series.

b. Contacts 6-5 complete a circuit to the peg count meter (PC). This meter operates and registers the number of times one allotter has operated.

c. Contacts 3-4 open the operating circuit of relay GD. Relay GD does not release at this time, because it is locked up over its own contacts 25-26.

d. Contacts 26-27 prepare the path to the Y magnet for Y direction stepping.

e. Contacts 7-8 prepare a circuit for operating relay SW.

f. Contacts 1-2 break and open the circuit to relay YD.

Relay YD releases. Relay YD, being slow to release, remains operated for a short time and then releases. The contacts of the relay function as follows:

a. Contacts 1-2 open the alternate lockup circuit of relay YD.

b. Contacts 7-6 break and 6-5 make to transfer the circuit of relay PU from its ac to its bd winding.

c. Contacts 26-27 break and 25-26 make, transferring the circuit from the X magnet to the Y magnet.

d. Contacts 3-4 partially complete a circuit to relay YS.

e. Contacts 24-23 complete the operating circuit of relay PA.

Exercises (606):

1. List the operated devices in the operating circuit of the XY switch X magnet.

2. From what source does terminal 7 of the X-XX bank terminals get the potential that operates the allotter XS relay?

3. Identify the operated relays for completing the operating circuit of the Y magnet.

607. Using foldout 1's XY diagrams, name the linefinder components that step the XY switch in the Y direction.

Stepping in Y Direction. The Y magnet armature moves the Y driving pawl to turn the cog roller: and T, R, S, and HS wipers move one step in the Y direction. (The X-XX wipers do not move during Y direction stepping.) The Y off-normal (Y-ON) springs operate as the wipers take the first step and remain operated. The Y interrupter springs (Y-IS) are opened before the Y magnet completely operates. The circuit to relay PA is opened by these contacts, thus releasing relay PA. Relay PA opens the circuit to the Y magnet when its contacts 2-3 open.

With the circuit to the Y magnet opened, the armature of the Y magnet starts to return to its normal (unoperated) position. However, before it reaches its normal position, the Y-IS close and again complete the circuit to relay PA. Relay PA operates and again completes the circuit to the Y magnet.

The Y magnet operates, moving the wipers one more step in the Y direction, and the Y-IS again open the circuit to relay PA. Relay PA releases and again opens the circuit to the Y magnet, and the Y magnet releases again.

This sequence of operation continues until the S wiper comes into contact with the resistance negative battery on the marked position of the S bank. If

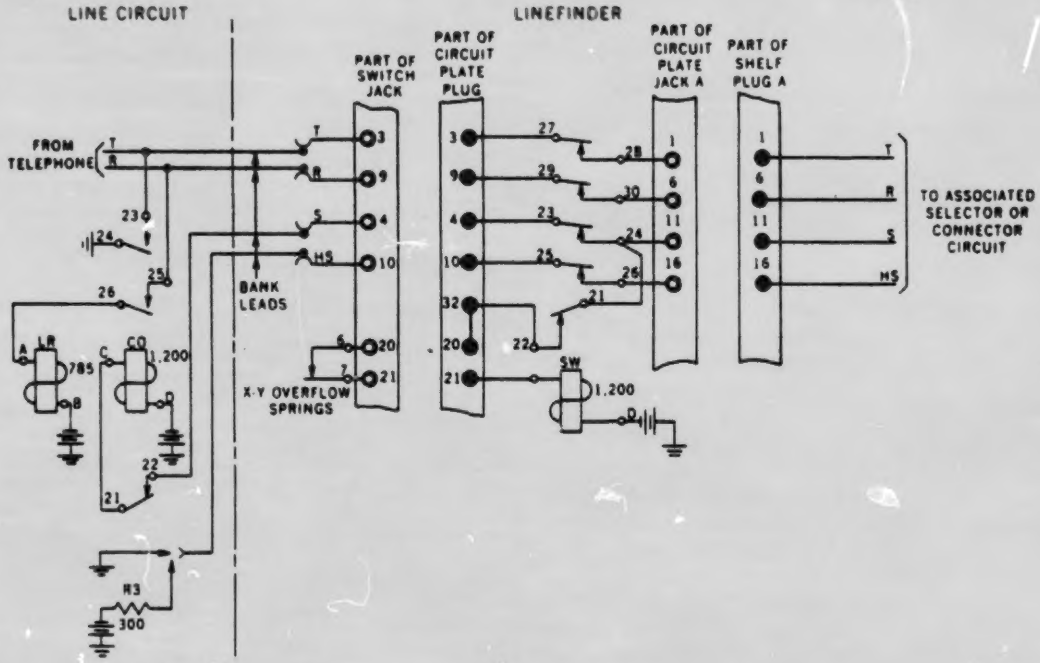


Figure 1-3. Telephone line extended to first selector.

resistance battery had been present on the first contact of the S bank, the wipers would take one step in the Y direction only. However, in this example, resistance battery is on position 5 of level 7. The wipers, therefore, take five steps in the Y direction; and the S wiper comes into contact with the resistance battery. This resistance negative battery relay YS is in series with relay CO in the line circuit.

Relay YS operates. The first function of relay YS is to break contacts 3-4 to open the circuit to relay PA. Relay PA releases at this time, and its contacts 2-3 open the circuit to the Y magnet. The remaining contacts of relay YS function as follows:

a. Contacts 7-6 make and 6-5 break to transfer the operating circuit of relay AS from its ca winding to its bd winding.

b. Contacts 8-9 open the circuit to relay GD. Relay GD, because of its slow-to-release feature, does not release at this time. It remains operated for a fraction of a second to allow other switching functions to take place before it releases.

c. Contacts 9-10 complete a circuit to the magnet of rotary switch A. Although its armature operates, the RX switch does not step until relay YS releases and opens the operating circuit to the winding of RX switch A. The driving pawl of RX then steps the wipers attached to the rotary mechanism to another contact.

d. Contacts 1-2 of relay YS complete the operating circuit of relay SW (switchthrough).

Relay SW operates. Relay SW operates and locks up through its own contacts 22-21 to ground received from the S lead of the succeeding equipment. This lockup path is independent of the allotter circuit. Relay SW remains operated as long as the next switch furnishes ground on the S lead. The remaining contacts of relay SW function as follows:

a. Contacts 31-32 further open the circuit of the release magnet (Z-FO 1) to prevent the release magnet from operating when relay ST releases. Contacts 34-35 complete a circuit from ground at contacts 8-7 of the busy switch to the bank contacts of both rotary switches. This ground marks this linefinder busy, on the banks of both rotary switches, to prevent the allotter from seizing it as other telephone users originate calls. Other busy linefinders mark their position on the banks of the rotary switches in a similar manner. This ground is removed when relay SW releases at the completion of the call.

b. Contacts 27-28, 29-30, 23-24, and 25-26 extend the T, R, S, and HS leads, respectively, from the line circuit through the linefinder to the associated selector or connector circuit. You can see these connections illustrated in text figure 1-3. Although this figure does not illustrate it, you should recall that the succeeding equipment connects ground to the S lead to hold the SW relay in the linefinder and the CO relay in the line circuit operated. In addition, the succeeding equipment returns dial tone to the telephone station over the T and R leads. Remember, too, the open contacts 25 and 26 at relay CO have released relay LR. As a result, ground is disconnected from the AST lead. With ground removed from this lead, relay SA releases. Relay SA performs no important functions during its release.

Relay GD releases. Because relay GD is a slow-to-release relay, the functions just described are performed before relay GD releases, and its contacts function as follows:

a. Contacts 21-22 remove ground from relay ST, which releases.

b. Contacts 5-6 remove ground from relay XS, which releases. These contacts also open the biasing circuit to the bd winding of relay YS.

c. Contacts 32-31 open the circuit to relay YS, which also releases.

d. The remaining contacts of relay GD are of no importance at this time.

Relay ST releases. Relay ST releases and its contacts function as follows:

a. Contacts 9-10 further open the circuit to the X magnet.

b. Contacts 1-2 disconnect the original bridge used to seize the succeeding equipment.

c. Contacts 12-13 further open the circuit to relay PA.

d. Contacts 6-7 open the originial operating circuit of relay SW, however, relay SW remains operated by its lockup circuit through its own 22-21 contacts (fig. 1-3).

e. Contacts 3-4 prepare a path for the release magnet. This circuit will be completed when relay SW releases (at the completion of the call).

Relay XS releases. Contacts 5-6 of relay XS open the circuit to the PC meter. The remaining contacts of relay XS perform no important functions at this time (FO 1).

Relay YS releases and rotary switch steps. Relay YS is the last relay in the allotter circuit to release. All of the relays of the allotter circuit are now in their normal positions and can be used again with another linefinder. The contacts of relay YS function as follows:

a. Contacts 9-10 open the circuit to the magnet of rotary switch A. The rotary switch releases; it moves its wipers one step to the terminals connected to the next linefinder circuit. If the next linefinder is not busy (ground absent from the G lead—guard lead), the rotary switch wipers remain connected to terminals of this linefinder.

b. If, however, the next linefinder is busy, ground on the G lead completes the operating circuit of rotary switch A. Rotary switch A operates its interrupter contacts to open its operating circuit. This releases the rotary switch and allows the driving pawl to move the wipers one step to the terminals of the next linefinder. However, when there is a ground on the G lead, the rotary switch continues stepping automatically until it encounters a linefinder circuit that is idle (absence of ground on the G lead). If all linefinders are busy, relay FB releases. The remaining contacts of relay YS are of no importance at this time.

Exercises (607):

1. Identify the devices which interact with the XY switch magnets to alternately operate relay PA in the allotter.

2. Name the allotter relays that are temporarily held operated after the operating circuit is opened so that additional connections may be made before the relay can be permitted to release.

3. List the devices in the operating circuit for rotary switch A.

608. Using foldout 1's XY diagram, determine the actions of linefinder components and the circuits for specified circumstances and list the devices in the XY linefinder release magnet's operating circuit.

Additional Circuit Actions. We have noted that figure 1-3 indicated that relays CO and SW are operated. It also shows that there is no equipment connected to the T and R loop of the calling station when relay CO is operated. This circuit will remain in this condition until the call is completed. Also, until ground is removed from the S lead.

Linefinder release. When a call is completed, the telephone user replaces the handset of the telephone on the cradle. This opens the T and R loop to the succeeding equipment (selector or connector). The succeeding equipment releases and removes ground from the S lead. This latter action releases relays SW and CO.

Relay SW releases. Relay SW releases and its contacts function as follows:

a. Contacts 27-28, 29-30, 23-24, and 25-26 open the T, R, S, and HS leads between the line circuit and the succeeding equipment.

b. Contacts 31-32 complete a circuit to the release magnet (Z). The release relay (RA) in the supervisory equipment and the release magnet operate in series.

Relay RA operates. Relay RA (shelf supervisory equipment) operates and its 1-2 contacts complete a path to the release (RLS) lamp. The RLS lamp lights after a timed delay.

Release magnet operates. The release magnet operates the release springs. It also provides mechanical movements necessary to restore the XY switch to normal. Contacts 4-5 of the release springs close and complete a circuit from ground through terminals 15 of the circuit plate plug and the switch jack, contacts 5-4 of the release springs, terminal 5 of the switch jack and shelf plug to the bank contact (level A) of the rotary switch. This ground is necessary to keep this linefinder marked busy in order to prevent the allotter from seizing the linefinder while it is releasing.

When the release magnet operates, the Y retaining pawl is disengaged from the cog roller by the release armature extension arms, and the cog roller returns to Y normal. This process also returns the T, R, S, and HS wipers to normal and allows the Y off-normal contacts to restore. The X retaining pawl is lifted clear of the X gear sprocket as it rotates to its normal position. During its return to normal, it slides the X rack to its normal position. It also slides the cog roller to X normal. The cog roller, returning to normal, allows the X off-normal (X-ON) springs to return to their unoperated position.

When contacts 3-4 of the X-ON springs break, the circuit to the release magnet (Z) and relay RA is opened, thereby releasing both. Relay RA releases to open the circuit to lamp RLS. Relay RA also opens the circuit to the common supervisory circuit.

Release magnet restores. When the release magnet restores, contacts 4-5 of the release springs break to disconnect ground from the G lead of the rotary switch banks. The linefinder is thus no longer marked busy, so it can be used again for another call.

Exercises (608):

1. List the devices in the operating circuit of the XY linefinder release magnet.

2. How do you know that an XY linefinder switch has failed to release?

3. What type actions occur during an XY linefinder release sequence?

609. Given typical situations involving XY circuit activities following an all linefinders busy condition, determine the events occurring and the connection of or signal used in each such situation.

Terminating a Call When All Linefinders Are Busy. Ground through contacts 11-12 of relay ST in the linefinder circuit is multipled to the ATB lead of all linefinder circuits served by both allotter A and allotter B. Thus, when a linefinder is seized and relay ST in the linefinder operates, one ground connection is removed from the ATB lead. So when all the linefinders are busy, all grounds are removed from the ATB lead. Now since ground on the ATB is necessary to complete the operating circuits of relay FB in both allotters, removal of ground will open the operating circuits of the FB relays and allow them to restore. Also, when relay FB restores in both allotters, contacts 6-5 will complete a circuit to the ST leads of the common supervisory circuit. Ground on the ST leads operates relays in this circuit to start the interrupter circuit. The latter circuit in turn provides for audible and visible alarms of the busy condition. The common supervisory relays operate about 2 minutes after the FB relays release. These things follow:

a. Contacts 21-22 of the FB relays in both allotters connect ground from contact 22 to the 10 interruptions per minute start (IPM ST) leads. The interrupter circuit will supply 10 IPM pulses over the 10 IPM lead to allotter B. The 10 IPM pulses are then supplied to the ATB meter. The ATB meter will register each time it receives a pulse to indicate the length of time that the linefinder-busy condition exists.

b. Contacts 23-24 complete the FBT circuit: but this circuit is not used in military exchanges. The remaining contacts of relay FB are of no importance at this time.

Exercises (609):

1. All linefinders are busy in an XY telephone switching center group. At this time, what chain of events is started?

2. An ATB condition exists in an XY central office. What connection and signal is used to indicate this condition?

610. Determine XY linefinder-allotter components and responses when a linefinder is found to be in trouble.

Transferring Allotter (Trouble in Linefinder). A linefinder is considered to be inoperative or faulty if it does not complete its linefinding operation within a specified period of time. Provision is made for disconnecting the allotter circuit from a faulty linefinder by stepping the rotary switch to connect the allotter to a succeeding idle linefinder. In the following example the allotter is disconnected from a faulty linefinder and connected to a succeeding linefinder. In this example assume that the circuit of allotter A has started to function, and that allotter relays SA, GD, YD, and PA, and linefinder relay ST have operated. The linefinder should now be stepping in the X direction; relay PA and the X magnet provide the stepping circuit. Further assume that the switch is out of adjustment and will not step in the X direction; this condition will result in the interrupter springs not opening.

Relay YD operates. Relay YD prepares a path for operating relay PU over the PU lead that goes to the interrupter circuit. The interrupter circuit applies a ground pulse to the PU lead about every 6 seconds. Each pulse lasts for 1/5 second and when this ground pulse appears on the PU lead, relay PU operates.

Relay PU operates. After this operation, the relay locks up through its own contacts 7-9. The contacts of relay PU function in the following manner: Contacts 27-28 prepare an operating path for rotary switch A. Contacts 5-6 open the circuit to relay PA. Contacts 3-4 prepare a locking circuit for relay YD. Contacts 25-26 close to prepare an operating circuit for relay AS.

Relay AS operates. The interrupter circuit supplies a 1/5 second ground pulse to the ECP lead about every 6 seconds. This ground pulse appears on the ECP lead about 5$^1/_2$ seconds after the ground pulse to the PU lead. The ECP ground operates relay AS, which locks up through its contacts 9-7. The other contacts of relay AS function as follows: Contacts 6-5 open the circuit to relay PA. Relay PA releases and opens the circuit to the X magnet, which releases. Contacts 21-22 complete the locking circuit of relay YD. Should relay YD release at this time, it would open the circuit to relay PU too soon. Contacts 1-2 complete the circuit to rotary switch A. (The rotary switch does not move its wipers until it releases. Interrupter springs 1-2 of the rotary switch open the circuit to relay GD. Contacts 1-2 of released relay GD open the operating circuit to relay YD, which does not release as its locking circuit is still completed). Contacts 3-4 prepare a circuit for operating relay TF in allotter B. Contacts 23-24 extend ground through the transfer lamp and R4 to the group through the transfer lamp and R4 to the group supervisory circuit. Contacts 26-25 and 28-27 break to prevent the ground from the next PU pulse from reoperating relay PU.

Relay PU releases. At this time the ECP ground pulse is removed and relay PU releases. Relay PU opens the circuit to the rotary switch and relay YD. Rotary switch A moves its wipers to the next idle linefinder, and the linefinder-allotter again starts to function. Relay SA remains operated because the AST lead is still grounded. Contacts 21-22 of relay PU restore and prepare a circuit to relay TF in allotter B. Relay TF in allotter B will not operate until the next ECP pulse to allotter B is applied by the interrupter circuit, about 5 seconds after relay PU releases.

Second linefinder faulty. If the second linefinder served by allotter A is faulty, the ECP pulse operates relay TF in allotter B. The contacts of relay TF will transfer the AST leads of allotter A to allotter B, which then serves all of the lines in the linefinder group.

Second linefinder not faulty. If the second linefinder severed by allotter A is not faulty, the circuit functions in a normal manner. When Y stepping is completed, relay YS operates, transferring the lockup path of relay AS from its ca winding to its bd winding. The magnetic field created by the bd winding opposes the magnetic field of the ca winding, releasing the relay. Contacts 9-7 of relay AS open the circuit to the bd winding, preventing relay AS from reoperating. Relay AS restores and allows the emergency stepping circuit to restore to normal. Ground is removed from the DA lead. Relay TF in allotter B is disconnected from the ECP lead of allotter B, and the PU lead of allotter A is reconnected to the relay PU.

Emergency allotter transfer takes place when, for example, allotter A encounters two faulty linefinders in succession. When this condition exists, relay TF in allotter B operates from ground on the ECP lead and closes its own holding circuit. The operated relay TF holding circuit is the same as that just described through terminal 17. But the ground is now transferred to the 11-13 contacts of relay TF. The ECP pulse which operates relay TF is described later.

The contacts of relay TF function as follows: Contacts 28-29 transfer the ST-A lead from relay SA of allotter A to relay SA of allotter B. This action opens the circuit to relay SA in allotter A, releasing it. Relay SA opens the circuit to relay GD, and the relays of allotter A restore to normal. Contacts 3-4, 5-6, 7-8, 23-24, and 21-22 of relay TF transfer the AST leads of the odd levels from the X bank to the XX bank. The transferred allotter has its transfer lamp lit through the contacts of relay AS, and the supervisory circuit gives an alarm. At this time allotter B serves all stations connected to the linefinder banks with which it is connected. Allotter A would function in the same manner if allotter B should fail and if relay TF in allotter A had operated.

If, after allotter transfer, the working allotter meets two linefinders in succession that are not working, the working allotter will not attempt to transfer back to the allotter out of service. It will instead continue stepping until a good, idle linefinder is found. An allotter that has transferred may be put back into service by manually operating its BSY and RST switch. This operation removes ground from the holding circuit of relay AS, which restores and opens the operating circuit of relay TF in the working allotter. Both allotters are returned to their normal conditions and are available to serve calls coming from the levels they normally serve.

Exercises (610):

1. Identify the XY allotter trouble transfer relays.

2. What XY linefinder elements are transferred following a switch having stepped to two faulty linefinders in succession?

611. Name XY linefinder-allotter components and actions that follow an allotter failure.

Transferring Allotter (Trouble in Allotter). If trouble should exist in an allotter and a call is originated by operation of a line circuit, the linefinder-allotter will function as follows. Assuming that AN odd-numbered line circuit originates the call, supplying ground over the AST lead, relay SA in allotter A will operate. Normally, relay SA completes a circuit to relay GD. In this example, assume that relay GD does not operate because of dirty contacts of relay SA. Since relay GD does not operate, the remaining functions of the linefinder-allotter circuit cannot be completed, and the allotter circuit will function as described below.

Relay PU operates. The first ground pulse supplied by the interrupter circuit completes a circuit to relay PU, operating it. The contacts of relay PU perform the following functions: Contacts 9-7 make before 8-7 break to complete a holding circuit to relay PU. Contacts 27-28 prepare a circuit to rotary switch A. Contacts 25-26 connect to ca winding of relay AS to the ECP lead.

Relay AS operates. About 5½ seconds after the PU ground pulse, the interrupter supplies a ground pulse over the ECP lead, to operate relay AS. The contacts of relay AS perform the following functions: Contacts 7-9 make before 8-9 break to complete a holding circuit to relay AS. Contacts 1-2 complete a circuit to rotary switch A. However, rotary switch A does not move its wipers until it releases. Contacts 29-27 make before 27-28 break to transfer the holding circuit to relay PU to the ground supplied by the ECP pulse. Relay PU will release upon completion of the ECP pulse. Contacts 25-26 break to prevent the next PU pulse from completing another operating circuit to relay PU. Contacts 23-24 prepare a circuit to the transfer lamp. Contacts 3-4 prepare a circuit to relay TF in allotter B.

Relay PU releases. At the completion of the ECP pulse, relay AS remains operated and relay PU releases. The contacts of relay PU perform the following functions: Contacts 27-28 open the circuit to the rotary switch, allowing it to step to the next idle linefinder. Contacts 21-22 further prepare the circuit to relay TF in allotter B.

Relay TF in allotter B operates. About 6 seconds after the first ECP ground pulse, another ECP ground pulse is provided by the interrupter circuit. This second pulse operates relay TF. Relay TF functions as explained earlier.

Relay SA releases. Relay SA releases after relay TF operates, and its 4-3 contacts open the circuit to the emergency start fail lamp. Relay AS remains locked up to contacts of the busy and reset switch. Its operated contacts 24-23 keep a circuit completed to the transfer lamp, which remains lit as an indication of the allotter transfer condition. Allotter B will handle all calls until the trouble condition is cleared or until the busy and reset switch is operated and restored to normal, transferring calls back to allotter A.

Exercises (611):

1. When trouble develops in allotter A, what relay transfers the AST leads to the second allotter?

2. What indication do you have that one allotter is serving all linefinders?

3. Name the component(s) that provide this indication.

1-3. Troubleshooting the Linefinder

The troubleshooting principles presented in the preceding volumes are also useful when locating XY system problems. Hence, you know that a trouble exists because symptoms denote the faulty condition. You isolate the trouble area by inspecting and operating the equipment and thinking about possible causes of the results. You eliminate from suspicion those components that are working. Then, you test the suspected circuit(s) and devices and again eliminate those that are good.

We will now look again at a sample trouble symptom and identify probable defective components.

612. Given XY telephone equipment trouble symptoms, use foldout 1's schematic diagrams as necessary to identify probable trouble(s) and state the proper corrective procedures.

Assume that the trouble is identified as noisy transmission reported by several subscribers in one group. You should think "What part of the equipment could cause this condition?" and "Is it an individual unit failure or a common equipment failure?"

You should realize that the most probable cause for this symptom is the drop wire at the subscriber's telephone. However, this trouble would affect only that one telephone. In the above example, more than one subscriber in one group reported the difficulty. Since we know that his condition is caused by a poor connection, we can look at text figure 1-3 and see that the line circuit can not be mechanically at fault, because it has no such connections. In the linefinder, however, you can see that the T & R wipers and the 27 and 28 and 29 and 30 contacts of relay SW are probable devices, which if dirty, would cause a poor connection. Of course, similar dirty connections in the selector and connector could give the same trouble symptom.

Since we are studying finders in this chapter, you would correct the trouble by, first, isolating the linefinder in the group that has dirty contacts. An inspection is probably the best method for doing this. Then, you would burnish the contacts for that particular linefinder.

Exercises (612):

Use foldout 1 and the text information to determine a probable trouble for each of the following reported trouble symptoms. Identify an appropriate corrective action for each:

1. The subscriber reports no dial tone. No other similar report has been received.

2. Linefinder has failed to switch through to succeeding equipment.

CHAPTER 2

Selector Equipment

AFTER THE linefinder has connected the subscriber line to a selector, it is time for him to dial a number. The selector in an XY switching center compares with the Step-by-Step selector in that it is a semiautomatic switch. It is seized without a number having been dialed. Now, its relays are ready to receive the pulses provided by the first dialed digit.

We will first review types of selectors, a selector circuit principle and then will describe XY selector circuit operations. Lastly, this chapter will provide an example trouble symptom and probable troubles that could cause that symptom.

2-1. Types of Selectors

You have learned that when more than 100 telephone lines are installed, selectors are installed so that each selector can serve a certain group of 100 telephones. Figure 2-1 illustrates the basic XY selector system. Accordingly, a linefinder connects with a selector and each selector's wipers moves over ten levels. Each of those levels connects with a group of connectors. Of course, selectors have general and special requirements to perform the specific tasks.

613. Using figures 2-1, 2-2, and 2-3 as required, give two general requirements of XY selectors and the reason subscribers should not dial two consecutive numbers too rapidly, and identify three selector types.

General Requirements for Selector Equipment. Selectors are shared equipment. Figure 2-2 is a diagram that shows selector sharing. You can see in this figure that the ten selector bank levels can be reached by both of the selectors. Thus, both selectors can connect with the 200 and 700 groups of connectors. Remember, we are showing only the 200 and 700 connector groups, although there are also

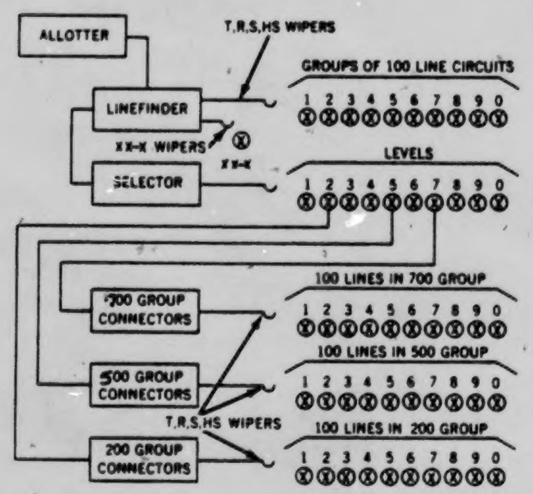


Figure 2-1. Basic selector system.

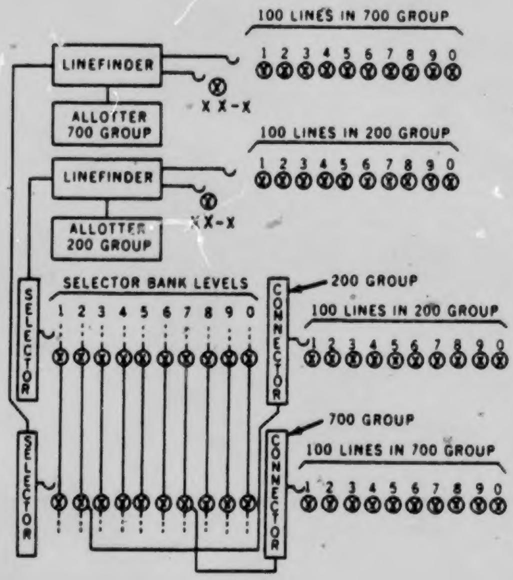


Figure 2-2. XY selector sharing (representative).

100, 300, 400, etc groups of connectors. To get the 200 connector group, the subscriber dials a 2.

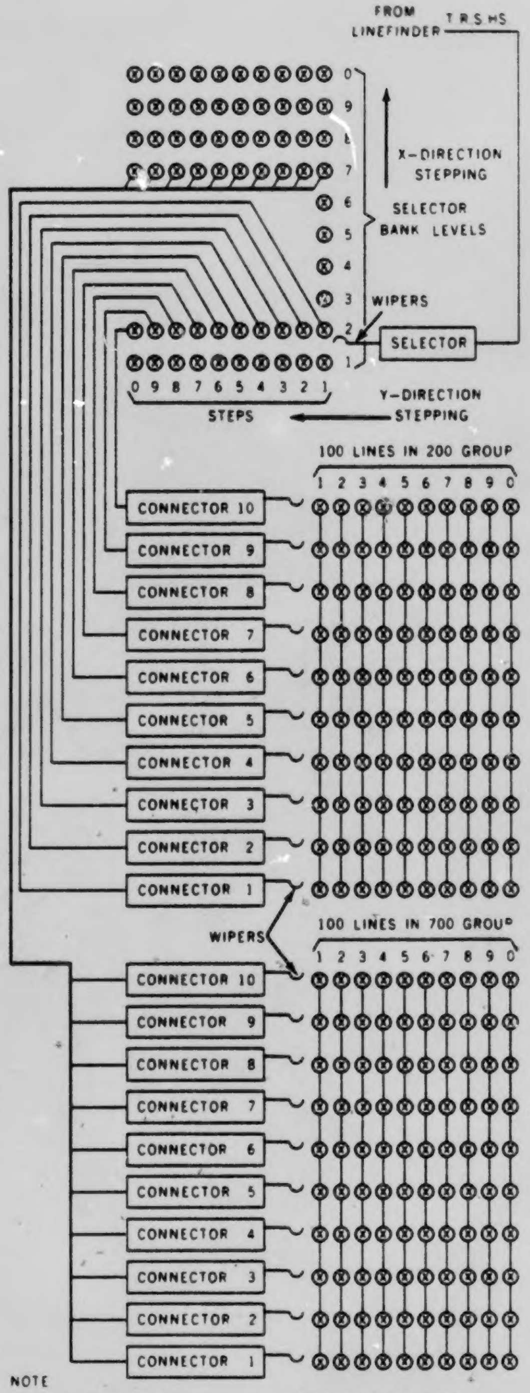
An XY selector may require several hundred milliseconds to search over the ten levels, engage the idle connector, and connect the pulsing leads to it. Most of this time is taken up in moving the wipers across the bank wires. The hunting speed of the switch is about 40 steps per second. Look now at text figure 2-3 as we consider the XY selector's operation in greater detail. Also, assume that the dialed digit is 2. The selector X-carriage moved the T, R, S, and HS wipers to the second level of the bank following this action. As soon as the dial pulses cease for the X direction stepping, the selector searches the 10 possible paths (by moving in the Y direction) in an attempt to locate an idle connector in the 200 group. As the Y carriage steps along the second level, its wipers search for an idle line. It repeats this procedure until an idle line is found or until it steps past the tenth set of contacts. When, as in this last situation, no idle line is available, busy tone is sent to the calling telephone as the switch steps into the eleventh position. Note: The eleventh position is not shown in the text figure. Should an idle line be located on the level searched, the selector will stop and connect the pulsing leads to the connector for completion of the call. This selector then remains in position (in use) for the duration of the call. Since any of the connectors associated with a particular hundreds group can locate any line in that hundreds group, it makes no difference on which level a selector finds an idle connector.

Selector Provisions. As additional groups of lines are added above 1000 lines, additional selection of groups of 1000 lines must be made. This second process of group selection is done by second selectors. A system with 100,000 lines requires third selectors.

In addition to connecting the groups of succeeding switches within the exchange, certain selector levels enable subscribers to dial directly to another exchange and obtain an operator when the distant exchange is manually operated or is a toll board. Individual trunks, when distributed to the selector banks in the same manner as are the connectors shown in figure 2-3, do not permit the use of the same selector level for both outgoing trunks and connectors. Incoming trunks in an XY office give access to individual incoming selectors, or they are terminated on line circuits in the same manner as are subscriber lines. Two-way trunks appear in selector banks for outgoing service and at incoming selectors for incoming service. Selector banks are also used to provide access for intercept service, reverting call, or other special services. Digit canceling selectors provide another example of how XY system service is furnished. In this case, a dialed digit may be absorbed, and the second dialed digit progresses the call to the succeeding equipment.

Exercises (613):

1. What requirement or connecting method provides



NOTE
T R S & HS CABLES (10 x 4) CONTAINING 40 WIRES BETWEEN THE SELECTOR AND THE CONNECTORS SERVED ARE TERMINATED AS SHOWN IN THE 200 CONNECTOR GROUP

Figure 2-3. Selector operation depicted.

Page 394 has been omitted but all materials are present.

that all selectors can access more than one connector?

2. When a selector has indicated to the subscriber that he is connected with it, what must he do to further operate the equipment?

3. Why shouldn't a subscriber dial two consecutive numbers at a very rapid pace?

4. Identify three types of selectors.

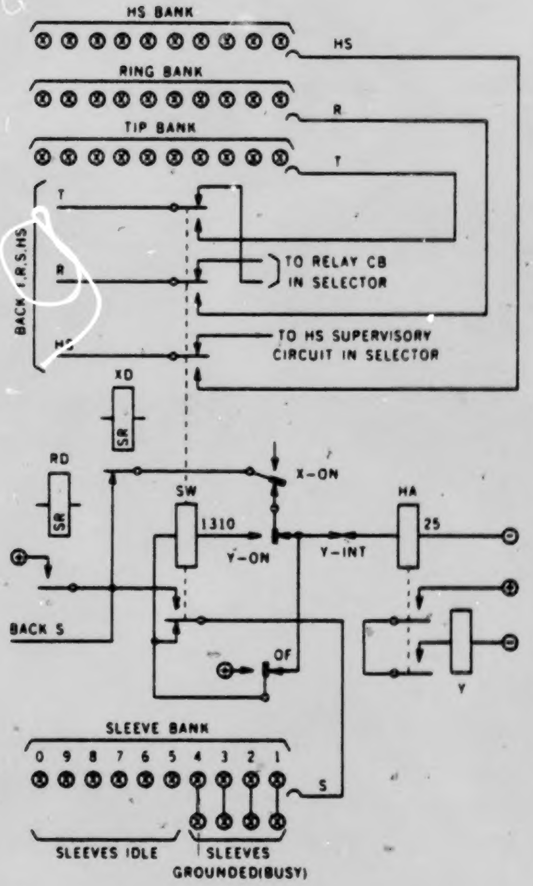


Figure 2-4. Absence-of-ground searching.

2-2. Selector Circuit Operation

The purpose of the selector is to single out a group of circuits under the control of the dial and then to hunt automatically for an idle path to that group.

614. Concerning a circuit operational principle related to absence of ground searching and a process whereby XY selector equipment accomplishes it, and using figure 2-4 as necessary, identify the potential at a bank sleeve preventing XY selector stepping, the factor making an XY selector switch step in the X direction, and whatever keeps relay SW from operating until Y direction stepping ends, and determine the selector S-lead potential and its source.

A Circuit Principle. Absence of ground searching is used when hunting for idle equipment in a given group. Text figure 2-4 may be used to consider this principle. In this illustration, the first four sleeves are shown to be busy (grounded). The condition of the circuit shown is that existing after the X digit has been dialed and the selector has been prepared for searching the selected level for either an idle trunk or an idle connector. Successful operation of the circuit depends upon the absence of ground on the sleeve bank. The absence of ground on a sleeve bank contact indicates an idle path or equipment, and the selector will be stopped from further search, remaining on that contact until the completion of the call.

The operation of the circuit shown in figure 2-4 is as follows: Release of relay XD, after completion of the dialed (X direction) digit stepping, operates the hunt assist relay HA through the Y off-normal (Y-ON) contacts. Relay HA operates the Y magnet, which advances the Y carriage and wipers one step, thus opening the Y-ON contacts. The HA relay is operated by a circuit through the Y interrupter contacts of the XY switch. Relay HA, therefore, does not remain operated after the Y interrupter contacts open. As the sleeve wiper advances, it prepares to test the first set of contacts in the sleeve bank to determine whether or not the circuit is busy. The ground which operates relay HA prevents the operation of relay SW. When the Y magnet operates, its interrupter contacts open the circuit of relay HA, releasing HA. It also removes the ground connection which operated the Y magnet. The Y magnet, therefore, returns to normal position. The sleeve wiper is now in position to test the circuit. If this circuit is grounded, as a result of being busy, relay HA is reoperated while the switch-through relay SW is prevented from operating. One of these grounds (shunt connections) originates at the contacts of relay RD, while the other ground is at the sleeve bank. The operation of relay HA operates the Y magnet. A ground on the S-lead from the linefinder prevents the operation of relay SW during the time the stepping of the XY switch in the Y direction along the bank level takes place. The operation of the Y magnet opens the

Y interrupter contacts, allowing relay HA to release, which in turn releases the Y magnet. Release of relay HA removes the ground from the S wiper and the wiper steps again. Thus relay HA reoperates, and the wipers advance whenever the circuit is busy, because of the ground on the S wiper. When the S wiper encounters a sleeve bank contact which is not grounded, relay SW operates in series with relay HA, because relay SW is no longer shunted by ground on the S wiper. The operation of relay SW completes the path to the succeeding switch for the tip (T), ring (R), sleeve (S), and helping sleeve (HS) leads. When the succeeding circuit operates, it busies the bank contacts seized by this selector. The sleeve ground returned by the succeeding circuit holds relay SW operated in series with relay HA, which does not operate, because of its low resistance.

Exercises (614):

1. What potential at a bank sleeve prevents an XY selector from stepping?

2. What causes an XY selector switch to step in the X direction?

3. Using text figure 2-4, determine both the potential on the selector S lead and where it comes from.

4. What prevents relay SW from operating until Y direction stepping is completed?

615. Using foldout 2's XY selector diagram, identify or list equipment that is seized following a call origination and compare X and Y direction stepping requirements for an XY system selector.

Seizure of Nondigit Canceling Selector Switch. Use the schematic diagram given in foldout 2 to trace this circuit operation. Some of the parts of the XY switch, such as contact 7 of the X off-normal springs and the lead to terminal contact 31 in the switch jack, are not used in selector operation. However, since this wiring appears in the XY switch at all times, it is shown in foldout 2 (found in a separate inclosure) even when the contact 31 of the circuit plate plug is left blank in the schematic for this selector. Note also that the X magnet interrupter spring contacts 1-2 are wired to contacts 12 and 13 of the switch jack, but no connection is shown at the terminals of the circuit plate plug. The interrupter spring contacts of the X magnet are not used in the selector, because the X direction motion is controlled by the dial pulses. The Y magnet interrupter spring contacts 1-2 are shown wired to contacts 17 and 11 of the switch jack in foldout 2. These contacts of the XY switch are necessary in the selector circuit, because the switch must search in the Y direction for an idle path to the group selected by the dial controlled X direction stepping of the same switch. The contacts 17 and 11 of the circuit plate plug are, therefore, wired to provide power connection for automatic stepping of hunting action. These step-by-step dial controlled or automatic stepping actions are described in this section.

The nondigit-canceling selector circuit seizes the selector when relay CB, shown in foldout 2, operates. The circuit to relay CB (calling bridge) is from the user's telephone over the T and R loop through the preceding equipment to the windings of relay CB.

Relay CB operates. The 4-5 contacts of relay CB are pulsing contacts, following the dial pulses of the calling telephone. When contacts 1-2 close, they complete a circuit to the monitor (MON) lamp, which glows brightly. The lighted lamp indicates to maintenance personnel that the circuit is seized and is ready to be used. This monitor supervisory (MSR) lead is first connected to the shelf supervisory equipment, and then in multiple with other MSR leads to the row of supervisory equipment. Contacts 4-5 of operated relay CB complete the operating circuit for relays RD (release delay) and XD (X direction).

Relay RD operates. Relay RD operates five sets of contacts to close or open circuits as described in the following paragraphs:

a. Contacts 5-6 complete a circuit from ground through the busy switch to the S lead. This circuit, a part of which is shown in foldout 2, keeps the preceding equipment operated. The 5-6 contacts perform other functions which will be described later.

b. Contacts 21-22 complete a circuit between the S wiper and the winding terminal of relay HA (hunt assist) to prepare for stepping the XY switch wipers automatically in the Y direction to locate an idle trunk.

c. Contacts 3-4 supply ground, over the ST1 (start 1) lead, to the common supervisory equipment, which supplies tone and ringing current.

d. Contacts 1-2 prepare an alternate circuit for operating relay XD after the first step in the X direction, and on each succeeding step, until stepping the X direction has been completed.

e. Contacts 24-23 break to open the circuit of the release (Z) magnet and prevent its operation after the X off-normal contacts 3-4 connect the Z magnet circuit as they operate during the first X direction step.

Relay XD operates. The contacts of relay XD make or break five circuit connections, as described in the following paragraphs:

a. Contacts 25-23 make before contacts 24-23 break to maintain the operating circuit for relay CB.

When this selector must supply tone, the circuit of relay CB will be extended to ground through the dial tone coil in the shelf supervisory equipment, and the telephone user will hear dial tone. If dial tone is not required, ground for relay CB is supplied through terminal 30 of the shelf plug. (For all of this, see FO 2.)

b. Contacts 22-21 break to prevent relay HA from operating prematurely immediately after the X off-normal spring contacts operate on the first X direction step.

c. Contacts 3-4 break to prevent relay HA from operating during continued X direction stepping when F wiring connection is in use, as is shown in foldout 2.

d. Contacts 1-2 close to prepare the circuit in the X magnet. The final closing of the circuit to the X magnet is completed by the release of relay CB.

Exercises (615):

1. Compare the requirements for X and Y direction stepping of an XY system selector.

2. Specify the XY selector components that operate during seizure of the circuit.

3. Identify the relay contacts that connect dial tone to the calling telephone line.

616. Using figure 2-5's XY selector diagrams, name components or circuit conditions that provide X direction stepping and identify two selector circuit devices which operate alternately to step the XY switch in the X direction.

X Direction Stepping of XY Switch. At this point the switch has been seized by the operation of relays CB, RD, and XD; the circuit of the X magnet is prepared; and the telephone user receives dial tone. The switch is thus prepared for stepping in the X direction under the control of the dial at the calling telephone. Text figure 2-5 is a simplified selector diagram that shows the operating circuits for these three relays. In addition, you can trace the X magnet operating circuit and determine that its circuit is complete following release of relay CB. Further, you can trace from the tone transformer connection to the tip lead of the linefinder.

X direction stepping occurs when the pulse springs of the dial break to open the T and R loop to release relay CB.

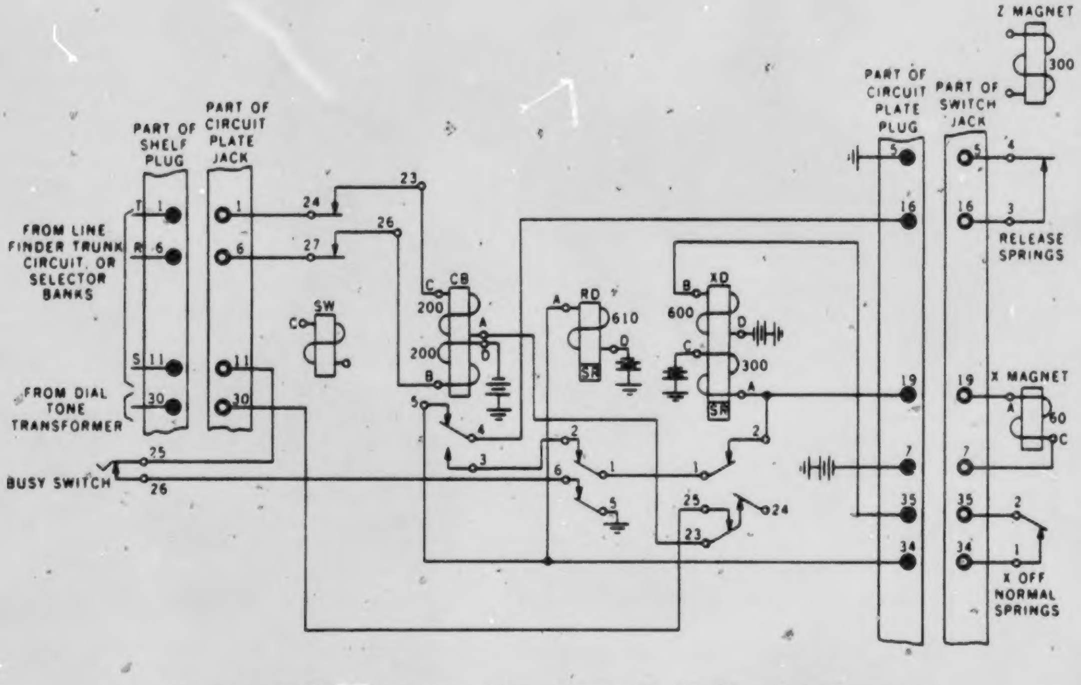


Figure 2-5. Simplified selector circuit diagram for relays CB, RD, XD, and the X magnet.

Relay CB releases. The released CB relay does the following:

Contacts 1-2 open to extinguish the MON lamp. Contacts 4-5 open the circuit to relays RD and XD. Slow-to-release relay RD remains operated during the stepping procedure, and relay XD has an additional circuit through winding ca completed by contacts 4-3 of relay CB.

X magnet operates. Operation of the X magnet moves the switch wipers one step in the X direction. The X off-normal springs operate during this first step and contacts 1-2 open the circuit to the bd winding of relay XD. At about the same time that the X magnet completed this first step, the dial pulse springs close again across the T and R loop, completing the circuit for relay CB.

Reoperation of relay CB. After the first step in the X direction, relay CB completes the circuit to the MON lamp at contacts 1-2, reenergizes relay RD by closing contacts 4-5 (relay RD remains operated during pulsing, because it is a slow-to-release relay), opens the circuit to the X magnet releases, and prepares to step the switch wipers further.

Relay CB releases for the second time. As the dial pulse springs open for a second pulse, relay CB releases to reopen the circuit for relay RD and to again complete the circuit of the X magnet at contacts 4-3. The wipers are now moved another step in the X direction. But again the dial pulse springs close, and relay CB is reenergized.

Continued X direction stepping. This interaction of the dial pulse springs, the X magnet, and relay CB continues until the X direction stepping is completed. The switch wipers are stepped one step for each dial pulse until the last pulse of the digit is completed. At this time, there is a dial pause, during which relay CB remains operated for a longer period of time than during the time for one pulse. During the dial pause, relay XD releases, preparing the switch for stepping the wipers in the Y direction.

Exercises (616):

1. Identify the two devices in the selector circuit which alternately operate to step the XY switch in the X direction.

2. Name an XY system component that can be observed to determine whether or not a selector is stepping.

3. What potential is at the X magnet winding at all times and tell where it comes from?

617. Using figure 2-6's XY selector diagrams, name all components or identify all circuit conditions that provide Y direction stepping.

Y Direction Stepping of XY Switch. Y direction stepping starts with the control relays in the following conditions:

Relay CB is operated by the closed T and R loop. Relay RD is operated by the closed contacts 3-4 of the release springs. Relay XD is held operated only because it is a slow-to-release relay.

As relay XD releases a short time after the last X direction step is taken, its 1-2 contacts shown in foldout 2, further open the X magnet circuit. Contacts 24-23 make before contacts 23-25 break to transfer the holding circuit of relay CB to ground at terminals 20 of the switch jack and circuit plate plug. Contacts 21 and 22 of the released relay XD complete the operating circuit for relay HA. You can trace this circuit easily in text figure 2-6. Accordingly, battery for the HA is connected to terminal 7 at the circuit plate plug, and ground is connected to contact 5 of relay RD.

Relay HA operates. Operated relay HA makes contacts 1 and 2 and 3 and 4 and breaks contacts 5 and 6. Contacts 5 and 6 open the operating circuit for this relay. Contacts 3 and 4 complete a shunt circuit for relay SW. (*Note:* This circuit is not shown in fig. 2-6.) Contacts 5 and 6 of relay RD also shunt relay SW, when the S wiper is positioned between bank contacts during stepping in the Y direction, to prevent operation of relay SW until Y stepping has been completed. Operated contacts 1 and 2 complete the operating circuit for the Y magnet.

Y magnet operates. As the Y magnet operates and moves the T, R, S, and HS wipers one step into the bank, the Y off-normal springs operate and extend ground through the 6-5 contacts to the winding of relay SW from the 5-6 contacts of relay RD. When the Y magnet is operated, its interrupter springs (1-2) open the circuit to relay HA.

Relay HA releases. As relay HA releases, its 6-5 contacts reconnect a circuit to its ca winding. Its 4-3 contacts remove the shunt from the operating circuit of relay SW, so that relay SW may operate if the wire bank contact is not grounded. Contacts 1-2 open to release the Y magnet.

Y magnet releases. As the Y magnet releases in preparation for another step, if necessary, its interrupter springs complete a circuit from negative battery through the winding of relay HA to the S wiper.

After this first step in the Y direction has been completed, relay CB is operated over the T and R loop. Relay XD is released, and relay HA has its ac winding connected in series with the S wiper and is prepared to operate if ground is encountered by the S wiper. The ac winding of relay SW is connected to ground at contacts 6-5 of relay RD and to the S wiper and one end of the ac winding of relay HA. Should the

S wiper encounter ground on the S bank lead, relay SW will be shunted to prevent it from operating, and relay HA will again operate as we have described previously, causing the switch to step another step in the Y direction. This alternate operation of relay HA and the Y magnet will continue to step the switch wipers in the Y direction until the eleventh position is reached, unless the S wiper encounters an absence of ground. If the S wiper encounters an absence of ground on the S lead, relay SW will not be shunted, and relay HA will not operate. Relay SW will operate under this condition, in series with the ar winding of relay HA, and a switch-through will take place, as we will describe later on in this section.

Exercises (617):

1. What XY selector circuit condition causes the XY selector switch to step in the Y direction?

2. What equipment condition is indicated when the selector S wiper encounters an absence-of-ground on an S bank contact and what action does the selector take?

3. Name the XY selector components that alternately operate to step the XY switch in the Y direction.

618. Identify XY selector responses to an all trunks busy condition by labeling the actions or listing the relays and relay contacts and magnetic springs involved at such a time.

Terminating a Call When All Trunks Are Busy. If all of the trunks in the dialed level are busy, all bank wires in that level are grounded. As a result, relay HA and the Y magnet will continue to move the wipers one step at a time to position Y-11, operating the XY overflow springs. The calling station will then receive a busy tone, indicating that no idle trunks are available.

As the overflow springs operate, contacts 4-5 open the circuit to relay SW and prevent its operation. Contacts 7-8 extend the ca winding of relay CB to busy tone ground. Relay CB will release during the ground transfer period, but this will not affect the required circuit functions.

Calling station disconnect. Having received a busy tone, the calling subscriber replaces the telephone on

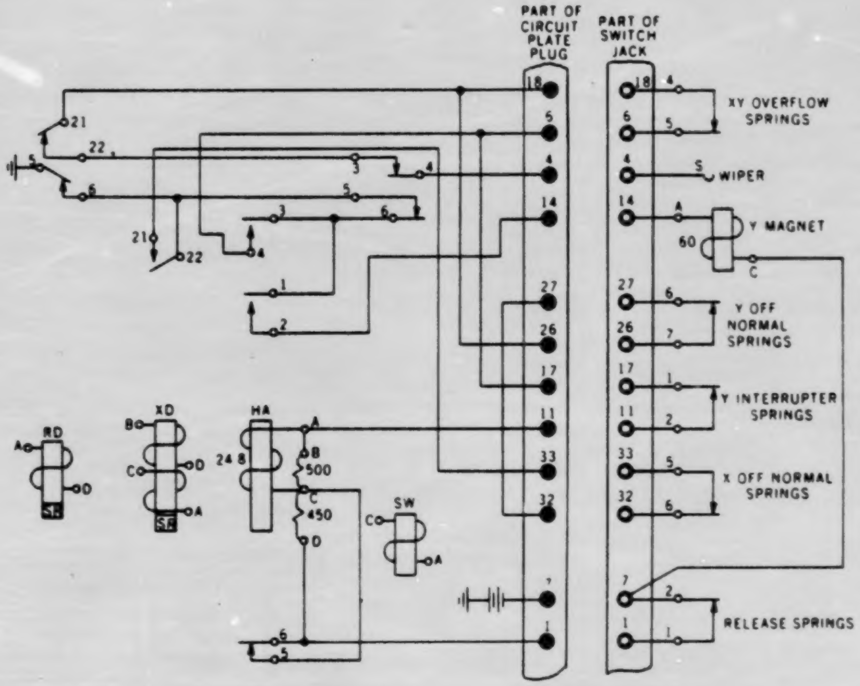


Figure 2-6. Simplified Y-direction stepping circuit.

the cradle. This act opens the T and R loop. Now, relay CB in the selector circuit releases.

Relay CB releases. Contacts 4 and 5 of the released CB open the operating circuit of relay RD. Contacts 3 and 4 close but perform no useful function at this time.

Relay RD releases. Released relay RD disconnects ground from the common supervisory circuits by opening contacts 3-4. Contacts 21-22 disconnect the S wiper from the SW and HA relays to prevent operation of these relays during the time the XY switch wipers are returning to normal. Contacts 6-5 remove the ground from the S lead and allow the preceding equipment to release. Contacts 24-23 complete the circuit to the Z magnet.

Z magnet operates. The release springs operate and remain operated until the switch has returned to the X normal position. Release spring contacts 1-2 open to prevent relay HA from operating during the release of the switch. Contacts 4-5 extend ground to the preceding equipment over the S lead to prevent the selector from being seized while the release is in progress. As the switch returns to Y normal, the Y off-normal springs restore, and the X off-normal springs also return to normal to open the circuit to the Z magnet, allowing it to restore to the normal position. The switch is now ready to be used for another call.

Exercises (618):

1. Name the actions that occur in the XY system selector when the circuit finds that all the trunks are busy.

2. Specify the relays and relay contacts and magnet springs that are in the busy tone circuit of the XY selector.

619. Using figure 2-6 and foldout 2 as necessary, indicate XY selector component responses when a trunk is available by naming the actions, relay and magnet contacts, and relay contacts involved at such a time.

Switch Through When a Trunk is Available. The selector automatically hunts in the Y direction until its S wiper meets an absence of ground condition. At that time the selector will switch through and seize the succeeding equipment. During Y direction stepping, relay SW is shunted if the wipers rest on a busy trunk (or by ground through contacts 3-4 of relay HA) and, therefore, cannot operate. When an idle condition exists, however, the shunt is removed from relay SW, and it operates.

Relay SW operates. Text figure 2-7 illustrates the

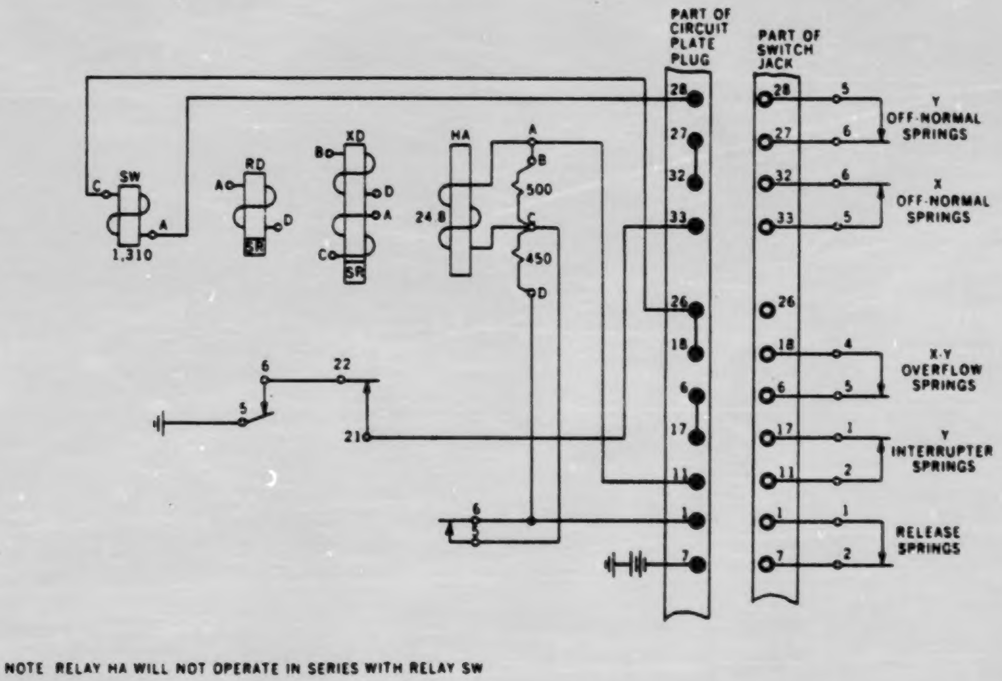


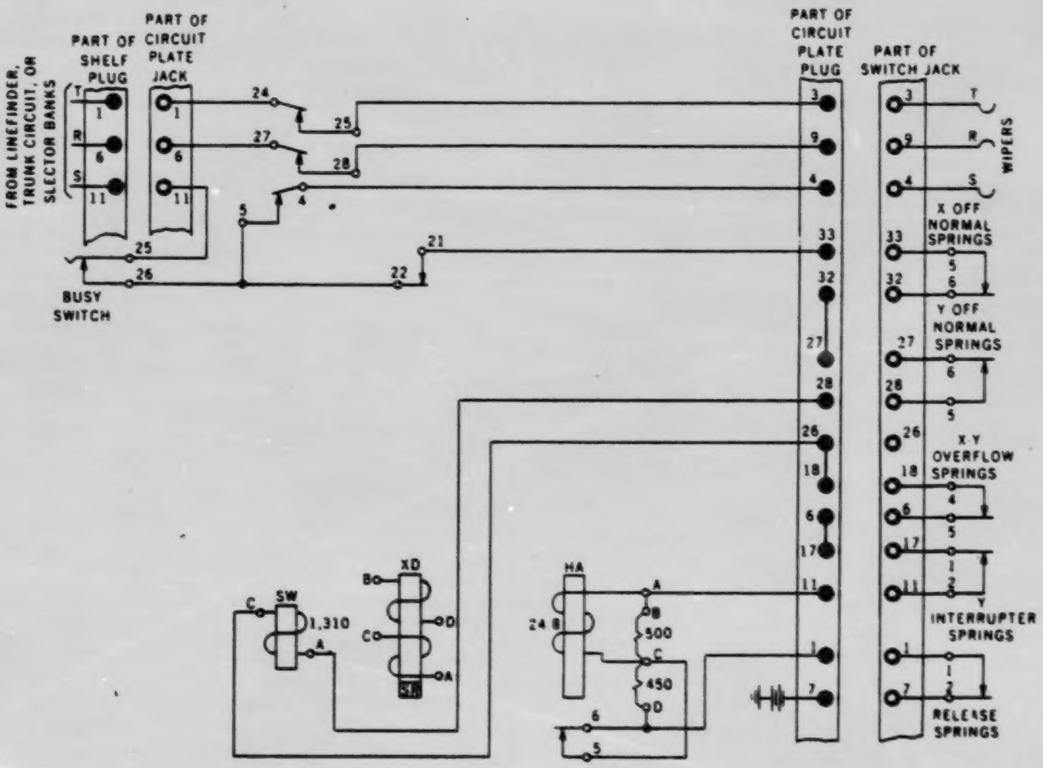
Figure 2-7. Simplified operating circuit for relay SW.

SW relay operating circuit. You should remember that the operating circuit for many of the components that we have traced so far terminated at the same terminals shown in this illustration. Using foldout 2, you should also note that when relay SW operates, its 22 and 21 contacts open the circuit to the release magnet. Contacts 1-2 connect resistor R3 in series with the MON lamp. When CB releases, later, this connection will allow the MON lamp to glow dimly instead of brightly. Contacts 5-4 close to prepare a holding circuit for relay SW through the S wiper from the succeeding equipment. This circuit is not used until a ground is later applied to the S lead. Contacts 5-4 also connect ground to the succeeding switch to mark it busy at the selector banks until relay RD operates. Contacts 3-4 also break at this time to prevent relay HA from operating during the switchthrough period. Contacts 24-23 and 27-26 open the circuit to relay CB, allowing it to release. Contacts 24-25 and 27-28 extend the T and R leads to succeeding equipment, thus, seizing it. Contacts 8-9 extend the HS lead to the succeeding equipment.

Relay CB releases. Contacts 1 and 2 of the released CB relay open the circuit to the MON lamp and its 5-4 contacts open the circuit to relay RD. The MON lamp will remain lighted, however, from the circuit established through resistor R3 to give a visual indication of busy condition. Relay RD, which is slow to release, remains operated for a short period of time and keeps the ground on the S lead to hold the preceding equipment operated until the switchthrough is completed.

Relay RD releases. The released RD relay completes the switchthrough procedure. Its 5 and 6 contacts open the original operating circuit of relay SW and remove the selector ground from the preceding equipment. Relay SW and the preceding equipment now remain operated because of the ground supplied by the succeeding equipment. Contacts 3-4 remove ground from the ST1 lead of the common supervisory equipment. Contacts 24-23 close to prepare a circuit for the Z magnet, which will be operated after relay SW releases at the completion of the call.

The switchthrough procedure is completed by the selector when the succeeding equipment is seized, and relay RD in the selector has released. The T and R leads from the calling telephone are now extended to the succeeding switching equipment, and the



NOTE: RELAY HA WILL NOT OPERATE IN SERIES WITH RELAY SW

Figure 2-8. Simplified XY selector call during call.

telephone user can now dial additional digits to step this equipment until the desired telephone station is connected and given a ring. Relay SW remains operated for the duration of the call.

Exercises (619):

1. Give three actions in the XY selector that follow when the wipers find an idle trunk to a connector.

2. Specify the relay and magnet contacts in the SW relay operating circuit.

3. Name the relay contacts in the linefinder and selector which extend the subscribers line to the connector.

620. Using figure 2-8 as necessary, identify XY selector connections and operations that restore the equipment following call termination and list the XY selector devices releasing at this time.

Selector Release After Completion of Call. The selector does not release until the succeeding equipment releases relay SW and permits the switch to return to normal, ready for another call. Release of relay SW takes place when the ground is removed from the S lead. This opens the circuit to the relay winding. Figure 2-8 permits you to trace the SW relay circuit to the S wiper. You find that during this tracing, contacts 5 and 6 of the X and Y off-normal springs and contacts 21 and 22 of relay XD and 4 & 5 of relay SW are in this S wiper circuit. Of course, the same ground potential from the connector is to be noted at the S lead for the linefinder, because of the closed 25 and 26 contacts at the busy switch.

When relay SW releases, its 24-23 and 27-26 contacts prepare the operating circuit of relay CB. Contacts 4-3 and 8-7 close to restore the S and HS leads to their normal circuit condition. Contacts 1-2 open the circuit to the MON lamp. Contacts 21-22 complete the circuit to the Z magnet.

When the Z magnet operates, its 4-5 release spring contacts extend ground to the S lead of the preceding equipment to prevent the selector from being seized while it is in the process of releasing. As the switch returns to Y normal, the Y off-normal springs return to normal; and at X normal, the X off-normal springs return to their normal positions. This opens the circuit to the Z magnet. When the Z magnet releases, the release springs restore to normal, and the switch is ready for another call.

Exercises (620):

1. Identify the potential that the XY connector removes from its preceding equipment to restore the equipment to normal.

2. State the XY selector devices that release following completion of the call.

621. Specify three XY selector features, including an installation method controlling subscriber access to XY system equipment, the selector devices test men use to check XY system equipment, and the electrical devices reducing high voltage arcing at telephone circuit contacts.

Additional Selector Features. Because of cost and time limitations, and since you study level restrictions for the XY system in the resident course, this feature is only reviewed in this manuscript. In addition to the level restriction review, we will mention the monitoring and spark suppression features.

F wiring. You have learned that several wiring methods are available; for example, F, Q, V, and Z wiring may be used. Foldout 2 shows the F wiring termination. To prevent access to certain telephone services, the F wiring is connected between terminal 7 of the circuit plate plug and jack and the restricted level terminal at the XX bank. Tracing from terminal 7, you go through contacts of relay SW, through contacts of the XY overflow springs, and arrive at terminal 16 of the circuit plate plug and jack. The HS lead from the linefinder is also attached at this terminal. Now, assuming that a calling station dials the digit 9, the seizure of the nondigit-canceling selector will be as usual. But upon completion of the first step in the Y direction, relay SW will be shunted at contacts 5-6 of relay RD and ground at the XX wiper. The ground on the XX wiper is supplied from the preceding equipment over the HS lead, through the circuit from the HS lead to the FF wiring and to position 9 on the XX bank. With this shunt across relay SW, the selector cannot switch through to the succeeding equipment during Y direction stepping. Relay HA and the Y magnet step the switch to position Y-11 to connect busy tone to the station orginating the call. When the station disconnects, the switch will be returned to normal.

Monitor devices. Operation of the busy switch prevents preceding equipment from seizing a selector. The monitor jack not only permits monitoring a call but also enables test-stepping the XY switch to any desired position. The connection of test equipment will be discussed in a later volume of this course. The monitor lamp indicates that the circuit is switched through. The lamp is not lighted when the selector is idle and is lighted brightly when the connector has been seized but has not switched through.

Spark suppression devices. Resistor R1 and capacitor C1 are connected in series from ground through contacts 3-4 of relay CB, as shown in foldout 2, to provide spark protection for these contacts. Resistor R2 and capacitor C2 are connected in series from ground through contacts 2-1 and 3-4 of relay HA to provide spark protection for these contacts.

Exercises (621):

1. What installation method controls subscriber access to XY telephone system equipment?
2. Specify selector devices that aid a test man checking XY system telephone equipment.
3. Name electrical devices which reduce high-voltage arcing at telephone circuit contacts.

2-3. Troubleshooting the Selector

You have seen that troubles can be isolated by analyzing the equipment operations and tracing from a point in the circuit where a signal is available to a point where no signal is noted. Of course, troubleshooting in the XY telephone equipment usually includes the operation of testing units and devices provided for this purpose. To illustrate, we have mentioned the busy switch and monitoring devices for the selectors. You should recall that the busy switch permits test-stepping of the XY switch while your are observing the monitoring lamp. In foldout 2 you should also have seen the test B jack. This jack enables testing of the XY selector while using the circuit plate maintenance test set.

You may sometime be required to open the circuit at a convenient point and test forward and backward. This test may thus isolate the trouble position. You may then open the defective portion in an effort to isolate the circuit further. Then, point to point testing reduces the defective section to smaller isolated areas.

From what we have just said, recall again that many methods may be used to locate troubles. With all methods, think logically and use care that you don't put troubles in while trying to correct what is already there.

We will again consider a sample trouble symptom and identify troubles which could provide such a symptom.

622. Given a typical XY telephone equipment trouble symptom, use foldout 2's schematic diagrams as necessary to determine the probable trouble(s) and the proper corrective procedures to be implemented.

Assume that during a routine test, you find that the selector can't be seized from the monitor A jack. We can consider two probable troubles for this symptom. See foldout 2. First, the test jack could be defective. Second, the pulsing (CB) relay could be failing to make contacts 1 and 2 and 4 and 5. Again, a visual inspection of each of the units may reveal whether or not the mechanical devices are failing to function. Dirty or maladjusted components are corrected as we have previously indicated. If relay CB appears to be nonfunctioning, you will have to check it electrically with the circuit plate maintenance test set, with a relay test set, or with an ohmmeter.

Exercises (622):

Use foldout 2 and text information to determine a probable trouble for each of the following reported trouble symptoms. In each instance, identify an appropriate corrective action.

1. Selector MON lamp is glowing during telephone system quiet period (no calls are being processed).
2. Test man receives a dial tone, but the selector does not switch through.

Connector Equipment

IN ALL PLAYS and movies a series of events lead toward a climatic point. At that point, events occur which complete the story. The connector can be considered as the climatic point in our telephone project. The events that preceded its seizure included operating relays in the line equipment, linefinder and first selector. The operated connector completes the connections which enable the two subscribers to converse.

As we noted in Volume 3, there are several types of connectors. We will again recall some types in this chapter. Then we will review the XY connector circuit operation and troubleshooting of this equipment.

3-1. Types of Connectors

The connector switch is connected back-to-back to the selector and extends the T and R leads of the linefinder to the called station. The connector circuit follows the pulses of the dial, prevents the preceding equipment from releasing, tests the condition of the line, returns a busy or ringback tone, rings the called station, furnishes transmission battery to both subscribers, and releases at termination of the call. One connector that does this is referred to as a "regular connector."

623. Identify two types of XY connectors and give a function of each.

The "trunk-hunting connector's" functions are similar to those listed for the regular connector. When stepped to a busy line, this connector will continue to step in the Y direction until it finds an idle line. If all trunks are in use, a busy tone will be sent to the calling party. This trunk hunting feature is provided by strapping the S and HS lead of each line (except the last) into a trunk-hunting group. You may recognize the trunk-hunting connector's function best if you think of the telephone service required during fund-raising campaigns. These connectors provide that all of the associated telephones (usually 10) can be reached by dialing the same directory number.

The "private exchange (PX) connector" also provides the functions listed for the regular connector. To illustrate, it is preseized by an associated linefinder before the linefinder finds the calling station line. It sends dial tone to the calling station, steps in the X and then in the Y direction in response to dial pulses, tests for busy condition of the called station, and extends busy tone to the calling station if the called station is busy. If the called station is idle, it extends ringing tone to that station and ringback tone to the called station. Transmission battery is supplied to *both* stations after the called telephone is answered. When the call is terminated, the connector releases itself and the equipment preceding it. (Note that the X and Y interrupter springs are not used in the connector, because the switch is stepped by the dial pulse spring.)

Exercises (623):

1. Identify two types of XY system connectors.

2. What in the switch train provides transmission battery for the subscribers?

3-2. Connector Circuit Operation

Foldout 3, bound in 2 separate inclosures, is the schematic diagram for the XY system PX connector. Use it when tracing and analyzing this equipment.

624. Using foldout 3's XY connector diagrams as well as figures 3-1 and 3-2 as necessary, identify equipment seized following a call origination and the potential connected to the HS wiper for the connector bank and state the devices providing such potential and the name of the XY connector pulsing relay.

Seizure. The connector is seized when relay ST in the linefinder circuit operates during the linefinding process. The operation of relay ST places resistor R1 across the T and R leads of the CB relay in the connector switch operating relay CB.

Relay CB operates. Figure 3-1 can be used to trace the operating circuits of relays CB, RD and RT in this connector. Accordingly, you can see that contacts 4 and 5 of operated relay CB complete the operation circuit for relay RD (release delay). These two contacts also complete an operating circuit for relay RT (ring trip).

Relay RD operates. Operated contacts 3 and 4 of this relay connect ground to the S lead of the preceding equipment. This action keeps relay SW in the linefinder and relay CO in the line circuit operated until the linefinder locates the calling line, shown in foldout 3. Contacts 1-2 perform no important function at this time. These contacts will later provide a ground for the operation of relay SW in the connector circuit after the switch has stepped in the Y direction. They also serve to lock the BT (busy tone) relay in the operated position if the called line is busy. Contacts 23-24 partially prepare the operating path for the X and Y magnets. Contacts 21-22 supply ground to the start (ST) lead. This circuit is shown in foldout 3. Contacts 25-26 open to prevent the Z magnet from operating when stepping in the X direction begins (FO 3). Contacts 7-6 complete the operating circuit for relay XD and lockup paths for relays RT and RD. These circuits are shown in simplified form in figure 3-2.

Relay RT operates. Relay RT operates slightly later than relay RD and slightly before relay XD. The contacts of relay RT perform the following functions: Contacts 1-2 and 23-22 complete lockup circuits for relays RD and RT. Contacts 27-28 open one path of a parallel circuit to the common supervisory equipment. (The make 26-25 contacts of relay SW keep the other parallel circuit closed—FO 3). Contacts 25-26 prepare an operating circuit for the X magnet, while contacts 25-24 further open the circuit to the Y magnet. Contacts 9-11 make, before contacts 9-10 break, to transfer the operating circuit of relay CB to the GDT lead, seen in foldout 3, which is connected to ground through the dial tone transformer. Contacts 5-4 and 8-7 partially complete a circuit to the T and R wipers. This path is not used until later.

Relay XD operates. Relay XD operates slightly later than relay RT. Its contacts perform the following functions. Contacts 23-24 further open the circuit to the busy tone source. Contacts 25-26 prepare lockup paths for relays RD and RT. Contacts 1-2 prepare an operating circuit for the X and Y magnets and an operating circuit for relay XD when the switch starts to step in the X direction. This additional operating circuit is required, because the X off-normal (X-ON) springs open the original operating circuit to relay XD on the first step in the X direction. Contacts 3-5 prepare the circuit for relay BT. This circuit is used during Y direction stepping to connect the S wiper, so that relay BT may operate if the called number is busy. Open contacts 21-22 prevent relay SW from operating

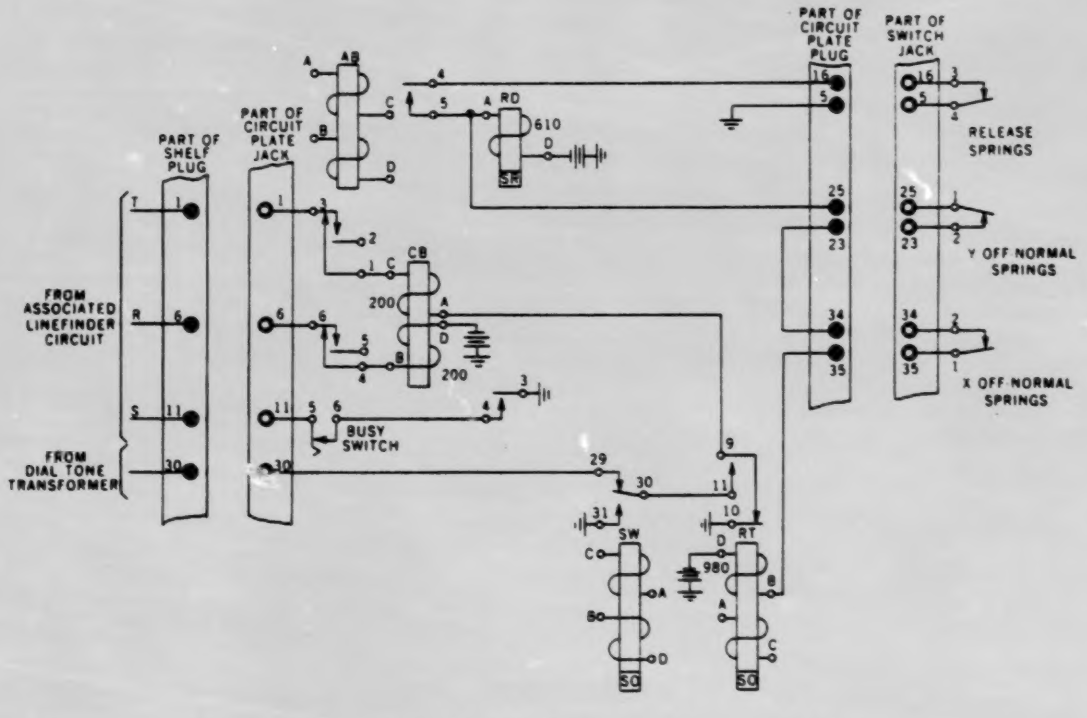


Figure 3-1. Simplified diagram for operating circuits of relays CB, RD, and RT.

prematurely. SW should not operate until Y stepping is completed and the called station is tested for busy condition. The circuitry just described is completed in about the same time the linefinder requires for searching out the calling party's line. As soon as the calling station receives dial tone, the desired station may be dialed. The operating circuit of relay CB is completed by the closed T and R loop to the calling station. Originally, the operating circuit of relay CB was closed by placing resistor R1 (in the linefinder circuit) across the T and R leads to the connector circuit. After the linefinder operation is completed, relay SW in the line circuit operates to extend the loop from the connector circuit to the calling station and relay ST disconnects resistor R1 from across the T and R leads. Relay CB is now connected over the T and R loop to the dial pulse spring contacts of the calling party's telephone, giving the dial direct control of relay CB. Each time the dial is used, relay CB releases and reoperates in response to the dial pulses. When the TENS digit is dialed, relay CB supplies a pulse to the X magnet each time it reoperates.

Exercises (624):

1. Identify the relays that operate to seize an XY connector for a calling subscriber.

2. What potential is connected to the HS wiper for the connector bank? Name the devices which provide it.

3. Name the XY connector pulsing relay.

625. Using foldout 3's XY connector diagrams, and figures 3-1 and 3-2 as required, state all components or circuit conditions that step the universal switch in the X direction.

X Direction Stepping of XY Switch. When the dial opens the T and R loop for the first time, relay CB releases.

Relay CB releases. The contacts of relay CB function as follows: Contacts 5-4 open the operating circuit of relay RD, as seen in figure 3-1. However, relay RD is still held operated by ground through its own 6-7 contacts, as shown in figure 3-2. Contacts 3-4 complete a circuit to keep relay XD operated after the circuit to its bd winding is opened by the X off-normal (X-ON) contacts when the XY switch makes its first step in the X direction. At about the same time that the X magnet moves the wipers one step in the X direction, the pulse contacts of the dial close to reoperate relay CB.

Relay CB reoperates. Reoperation of relay CB performs the following functions: Contacts 4-5 complete the ground circuit of relay RD through the 3-4 contacts of the Z magnet, keeping relay RD operated. Contacts 3-4 open the circuit to relay XD, which does not release because it is a slow-to-release relay and will be reenergized by the next release of relay CB. Contacts 3-4 also open the circuit to the X magnet, which releases, leaving the wipers one step in the X direction. During this time, relay RT is held operated by ground at the 6-7 contacts of relay RD.

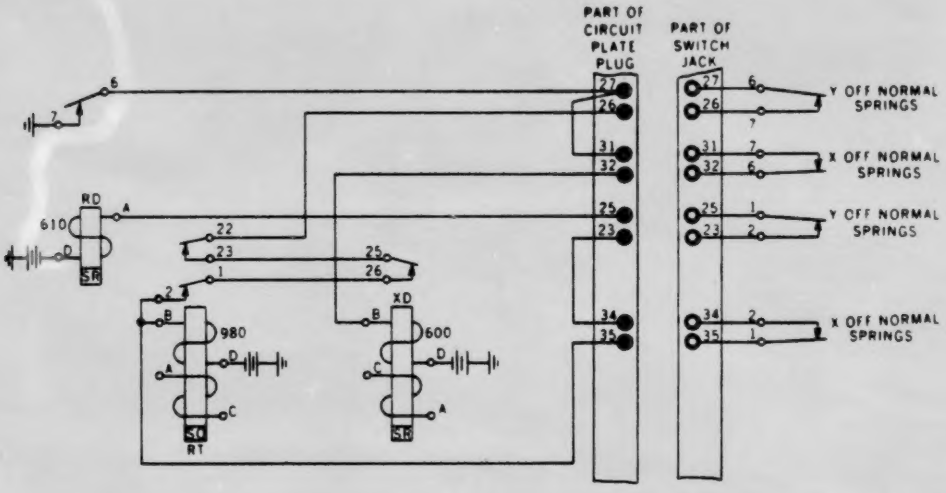


Figure 3-2. Relay XD operating circuit, relays RD and RT locking circuits.

Now that the X magnet is released, it is ready to receive another pulse to move the X-Y switch in the X direction.

Relay CB releases for the second time. Relay CB releases for a second time (when the dial pulse springs open for the second pulse), opening its 4-5 contacts and closing its 3-4 contacts. Contacts 4-5 open the circuit to relay RD; which cannot release for a short period of time because it is a slow-to-release relay. Contacts 3-4 complete a circuit for relay XD; reenergizing it before it has had time to release after the first dial pulse. These contacts also complete a path for the X magnet, which reoperates to move the wipers a second step in the X direction.

Relay CB reoperates for the second time. At the end of the second pulse, the dial pulse spring contacts close and complete the T and R loop to relay CB, which reoperates and functions as it did after the first pulse, remaining operated until the dial pulse contacts open for the third time. When the dial pulse spring contacts open, relay CB releases and functions as it did for the first pulse. Thus by operating and releasing in response to dial pulses, it controls the stepping of the connector XY stepping switch while it steps in the X direction. This interaction of the dial, relay CB, and the X magnet continues until the switch has been stepped the required number of steps, depending upon what digit was dialed.

Relay XD releases. If the digit 2 is dialed, the switch wipers move two steps in the X direction in response to dial pulses. When X direction stepping is completed, relay XD must release to change the circuit connections, so that Y direction stepping can take place. This is done during what is known as a dial pause. Dial pause is a length of time longer than the slow-to-release period of any affected relay, such as relay XD. When the last X direction pulse is received, relay CB operates and remains operated. Further pulses, for the second digit, will step the XY connector switch in the Y direction. Since relay CB remains operated longer between digits than between the dial pulses of a digit, relay XD will release during the dial-pause period.

Relay RT releases. When relay XD releases, its 25-26 contacts open the circuit of relay RT, as shown in figure 3-2, releasing it. Release of relay RT transfers the operating circuit of relay CB from the 9-11 contacts of RT to its 9-10 contacts, disconnecting dial tone from the connector circuit. Contacts 1-2 of relay RT open the circuit of its own b-d winding, preventing it from operating until after stepping in the Y direction is completed. Contacts 25-26 open to prevent the X magnet from reoperating during Y direction stepping. Contacts 24-25 prepare a circuit for operation of the Y magnet. This path for the Y magnet is completed after relay XD reoperates and relay CB releases. Contacts 22-21 of relay RT complete the operating circuit of relay XD.

Relay XD reoperates. After relay RT releases, relay XD reoperates. Contacts 1-2 further prepare a path to the Y magnet for Y direction stepping.

Exercises (625):

1. What procedure steps the XY system connector in the X direction?

2. Name the XY system connector relay that releases so that the connector may step in the X direction and which was not included on the selector circuit plate.

3. Give the function of the relay of question 2.

626. Using foldout 3's connector diagrams as necessary, identify the components or circuit conditions that step the XY switch in the Y direction.

Y Direction Stepping of XY Switch. Before the XY connector switch can step in the Y direction, relays CB, RD, and XD will be operated. Relay CB is held operated by the dial pulse contacts, relay RD is operated through the 5-4 contacts of relay CB and relay XD is operated through the 6-7 contacts of relay RD (fig. 3-2). Thus the switch moves in the Y direction under the control of the dial of the calling telephone. As the UNITS digit is dialed, relay CB in turn pulses the Y magnet. At the completion of dialing, relay CB is kept operated by the calling party's telephone. Let's again note the results when relay CB releases.

Relay CB releases. The 4 and 5 contacts of relay CB open the circuit of relay RD, but it does not release until the dial pause period, because it is a slow-to-release relay. Contacts 3-4 close a circuit for relay XD and the Y magnet. The circuit for XD is not important at the beginning of Y direction stepping, because it is held operated by negative battery at its db winding through contacts 6-7 of relay RD, as is shown in foldout 3. The circuit to the Y magnet operates the Y magnet to move the wipers one step in the Y direction for each dial pulse.

Y magnet operates. The Y-ON contacts open the circuit to the db winding of relay XD. Relay XD remains operated, however, over its c-a winding to ground, through release contacts 3-4 of the Z magnet. Relay XD does not release during pulsing, because it is a slow-to-release relay.

Relay CB reoperates. The T and R loop is closed by the dial pulse contacts after the first pulse is completed, and relay CB reoperates. Its 3-4 contacts open the circuit to the Y magnet and relay XD, as may be traced in foldout 6. Contacts 4-5 of relay CB reenergize relay RD. Relay CB remains operated until the dial pulse contacts at the calling station open; then relay CB releases.

Relay CB releases for the second time. When relay CB releases for the second time, its 5-4 contacts open the circuit for relay RD. Because it is slow to release, relay RD remains operated until after relay CB reoperates. Contacts 3-4 of released relay CB complete the circuit to reenergize relay XD. Contacts 3-4 also close the circuit to the Y magnet. The Y magnet moves the switch wipers the second step in the Y direction. The Y magnet remains operated until the dial pulse contacts at the calling station close the circuit to relay CB. Relay CB then reoperates.

Relay CB reoperates for the second time. At the end of the second pulse, the dial pulse contacts complete the circuit to released relay CB. Relay CB reoperates, performing the same function as those performed when it was previously energized and remains operated until the pulse contacts open for the third time. When the pulse contacts open, relay CB releases and functions as it did after the second pulse. Relay CB operates and releases in response to dial pulses. It controls the stepping the switch wipers in the Y direction.

Y direction stepping completed. At the completion of Y direction stepping, the T, R, S, and HS wipers are resting on the called station T, R, S, and HS bank wires; relay RD is operated; and relay XD releases. However, before relay XD releases, the connector tests the S bank wire to determine whether the called station is busy or idle. If the station is busy, relay BT (busy test) will be operated through the 3-5 contacts of relay XD before XD releases. If the called station is not busy, relay XD will release, and relay SW will operate to perform switchthrough procedures.

Exercises (626):

1. Using the telephone number 322-2714, which dialed digit(s) step(s) the XY connector in the Y direction?

2. Specify the contacts in the alternate operating circuit for the ca winding of connector relay XD.

3. Using the telephone number of question 1, how many times does the Y magnet operate?

4. Compare the operational function of connector relays BT and SW.

627. Concerning XY connector operations when a call is terminated because the called station is busy, name the operating circuit components for connector relay BT before relay XD releases and the operating circuit components for connector BT after relay XD releases, list the connector relay contacts in the busy tone circuit, and identify all connector components in the release sequence after reception of the busy tone and subscriber "hang up."

Terminating a Call When the Called Station Is Busy. When the called station is busy at the completion of Y direction stepping, relay BT operates from the ground potential on the S wiper bank contact. The contacts of relay BT operate as follows: Contacts 3-4 place an additional ground on the S lead of the preceding equipment as shown in foldout 3. This circuit is not effective at this time but will be needed later. Contacts 1-2 complete the busy tone circuit to the calling party.

When the telephone user at the calling telephone station hears the busy tone and hangs up, the T and R loop connection to the winding of relay CB is opened. As relay CB releases, its 4-5 contacts open the operating circuit to relay RD. When RD releases, its 1-2 contacts open the circuit to relay BT. This releases relay BT and disconnecting busy tone. Contacts 3-4 of relay RD remove ground from the S lead to release the preceding equipment, as seen in foldout 3. Contacts 25-26 of relay RD complete a path to the release (Z) magnet. Operation of the Z magnet releases the switch wipers. These are then returned to Y and X normal. In the meantime ground is supplied to the S lead to prevent the switch from being seized while it is releasing, as foldout 3 shows.

Exercises (627):

1. Name the components in the operating circuit for connector relay BT before relay XD releases.

2. Name the components in the operating circuit for connector relay BT after relay XD releases.

3. Specify the connector relay contacts in the busy tone circuit.

4. Identify the connector components in the release sequence following reception of the busy tone and subscriber "hand-up."

628. Identify XY connector operations that provide switch through when the called station is available, using foldout 3 and figure 3-3 as necessary.

Switchthrough When the Called Station Is Available. When the called station is available, resistance battery is on the S banks through the winding of the CO (cutoff) relay of the called station's line circuit. When the S wiper of the connector switch encounters this resistance negative battery, switchthrough procedures take place. Before switchthrough, relay CB is operated, relay RD is operated, and relay XD is operated, because it is a slow-to-release relay.

Relay XD releases. When relay XD releases and its 21-22 contacts complete the operating circuit for relay SW, the resistance of the db winding of relay SW is such that if two connectors contact the same terminal at the same time, neither of the SW relays involved will operate. This prevents two connectors from switching through on the same line at the same time.

Relay SW operates. When relay SW operates, it completes its own lockup circuit. Its 26-25 contacts open one of the two paths to the common supervisory equipment, as shown in foldout 3. Its 27-28 contacts open further the circuit to the Z magnet. This circuit is already open at the 25-26 (break type) contacts of relay RD. The 12-13 contacts prepare an operation path for relay AB. Relay AB does not operate until the called station answers. The 30-31 contacts prepare a new holding path for relay CB. This path is necessary when relay RT operates. Contacts 7-8 and 23-24 complete the ringing path to the called station. Contacts 9-10 partially prepare a path for the operation of relay AB. Contacts 5-6 prepare a circuit for the ringback tone. Ringback tone is supplied to the calling station through capacitor C4. Contacts 22-21 of relay SW extend the ground to the S wiper. This ground keeps the CO relay of the line circuit operated and marks the line busy to all other connectors. With the CO relay operated, the T and R leads to the calling station are cleared of all other equipment, and the connector can supply ringing current to the called station. The called station ringer will operate at intervals of one ring every fifth second, and ringback tone is supplied to the calling station at the same interval of time. Ringing current to the called station and ringback tone to the calling station continue until the called station is answered or until the calling party hangs up because there is no answer. Relay RT will not operate while ringing is in progress, though ringing current is passing through its ca winding, because it will operate on direct current only.

Relay RT operates. When the called station is answered, the lifted handset from the hookswitch shunts a capacitor in the set and provides a direct-current path which allows relay RT to operate. Since the ringing current was superimposed on the central office battery supply (GEN), lead RT will operate as soon as the capacitor is shunted to close the dc path. The X contacts of relay RT, as explained in Note 3 of foldout 3. The remaining contacts of relay RT operate as follows: Contacts 27-28 remove ground from the ST lead to the common supervisory equipment. The circuit to the supervisory equipment is no longer necessary, since the calling station has no further need for dial tone, ringback tone, or ringing current during the remaining time the called and calling stations are connected. Contacts 9-11 make before contacts 9-10 break, to change the operating ground for relay CB from contacts 9-10 relay RT to contacts 30-31 of relay SW. Contacts 3-4 and 6-7 remove ringing current from the called station and ringback tone from the calling station. Contacts 4-5 and 7-8 complete the T and R loop between the calling and the called stations. These contacts also complete the operating circuit of relay AB.

Relay AB operates. Relay AB operates to provide transmission battery to the called station.

It remains operated until the called party hangs up at the completion of the call. The contacts of relay AB operate as follows: Contacts 7-8 complete the lockup path to relays RT and SW. This path is necessary to prevent the connector from releasing until both parties hang up. Therefore, if the calling party hangs up first, relays RT and SW will remain operated, and the switch will not release. A second ground to relays RT and SW is supplied through contacts 6-7 of relay RD.

With the operating circuit of relay AB completed, the transmission path between the calling and called stations is established. During transmission, relays AB, CB, RD, RT, and SW are operated. The transmission circuit between the calling and called stations, shown in figure 3-3,A, is traced as shown in figure 3-3,B. Transmission battery is supplied to the called station through the db winding of relay AB. Since voice current is effectively alternating current, it passes readily through capacitors C1 and C2, so that the called and calling parties can talk to each other.

Exercises (628):

1. Which XY connector relay must release in order for the connector to connect the calling telephone with the called telephone?

2. How does the calling subscriber know that the selected telephone is being rung?

3. What XY connector relay receives ac and dc while the connector is connecting to the called telephone for the calling telephone subscriber?

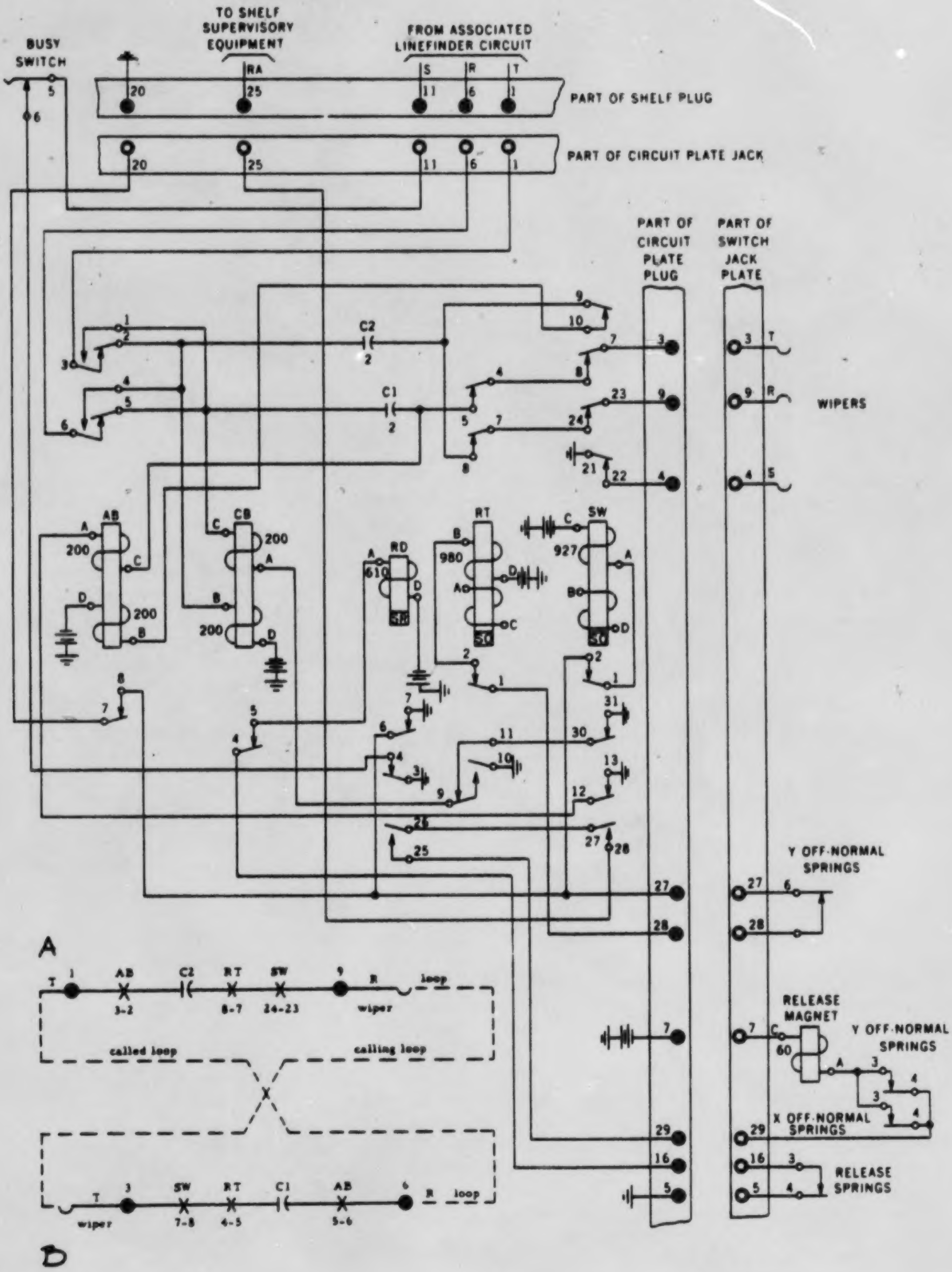


Figure 3-3. Transmission circuit through the XY PX connector.

4. What XY connector relay provides dc to the called telephone?

5. Identify the operated XY connector relays whose contacts make the circuit over which the conversation is held.

6. What XY connector relay provides dc to the calling telephone?

629. Give those connector conditions and actions which release the XY equipment following call completion.

Connector Release After Completion of Call. The connector will not release until both the calling and called parties have disconnected.

If the calling party disconnects first, relays CB and RD release; but relays AB, RT, and SW remain operated. If the called party disconnects first, relay AB releases, and relays CB, RD, RT, and SW remain operated. The release procedure for each of these conditions is described in the paragraphs which follow.

Calling station disconnects first. During transmission, relays AB, CB, RD, RT, and SW are operated. Relay CB is released by opening the T and R loop at the calling station. Contacts 5-4 of relay CB open the circuit to relay RD. Relay RD, a slow-to-release relay, releases after a short period of time to perform the following functions. Contacts 21-22 further open the ST lead to supervisory equipment. Contacts 25-26 prepare the circuit for the Z magnet. This circuit will be closed when relay SW releases. Contacts 3-4 remove the ground from the S lead to the preceding equipment, releasing the linefinder and line equipment, so that the calling station may initiate a new call if desired. Contacts 6-7 remove ground from the bd winding of relay RT and the ac winding of relay SW, but both of these relays remain operated by their other path to ground through the 8-7 contacts of relay AB. Contacts 6-5 complete the circuit to reoperate relay XD.

Relay XD reoperates and completes a circuit for relay BT. In operating, contacts 3-4 of relay BT supply ground over the S lead to the rotary switch banks, marking the bank busy. They also prevent the allotter from seizing the linefinder until the connector completely releases. Relays AB, XD, RT, BT, and SW remain operated under the control of the called station until that station disconnects, at which time the T and R loop between the connector and the called station is opened to release relay AB. Contacts 7-8 of relay AB open the circuit to relays XD, RT, and SW. Relays RT and SW release first, followed by relay XD, which is a slow-to-release relay. The contacts of relay RT perform no important function during the release operation. Release of relay SW completes, through its 27-28 contacts, the operating circuit of the Z magnet. Contacts 21-22 of relay SW open the circuit to relay BT, which releases.

Contacts 4-5 of the Z magnet supply ground over the S lead to the preceding equipment, marking it busy. The switch wipers restore to Y normal and then to X normal. As soon as the X-ON spring contacts restore, the Z magnet operating circuit is opened, and the Z magnet releases (restores). During the time the switch is restoring to normal, relay XD releases; but its contacts perform no important function at this time.

Called station disconnects first. When the called station opens the T and R loop, before the calling station disconnects, relay AB in the connector will be the first relay to release, operating its contacts as follows: Contacts 7-8 remove ground from relays RT and SW, which do not release because they have an added ground circuit through the 7-6 contacts of relay RD. Relay CB, RD, RT, and SW remain operated under the control of the calling station until it disconnects after the called station has disconnected first. When the called station disconnects under these conditions, the following operation takes place. Contacts 4-5 of relay CB open the circuit of relay RD, releasing it. When relay RD releases, its contacts operate as follows: Contacts 21-22 further open the circuit to the common supervisory equipment. Contacts 25-26 prepare the circuit to the Z magnet. This circuit will be closed when relay SW releases. Contacts 3-4 remove the ground from the S lead to the preceding equipment. This permits the linefinder and line equipment to release. Contacts 6-7 open the circuit to relays RT and SW, so that both these relays release at approximately the same time. When RT releases, its contacts perform no important function. When relay SW releases, its contacts perform the following functions: Contacts 21-22 remove the ground from the S lead of the terminating circuit. Thus the called station is now no longer marked busy and can receive or originate calls. Contacts 27-28 complete the circuit to the Z magnet. As the Z magnet operates, its 4-5 contacts supply ground over the S lead to the preceding equipment, marking it busy. The switch wipers restore to Y normal and then to X normal. As soon as the X-ON spring contacts restore, the Z magnet operating circuit is opened, and the Z magnet releases. While the switch is restoring to normal, relay XD releases; but its contacts perform no important function at this time.

Exercises (629):

1. When the calling station disconnects first, which XY connector relays release and which relays

remain operated until the called station disconnects?

2. When the called station disconnects first, which XY connector relay releases and which relays remain operated until the calling station disconnects?

3-3. Troubleshooting the Connector

You have seen that connectors complete the connections which permit the conversations between subscribers. It is evident, then, that these connectors require effective maintenance if the circuits are to be of good quality and most system users are to be satisfied.

We have noted that maintenance is most effective when the repairmen understand the system's construction and its operating principles. You should have little difficulty in understanding the XY connector maintenance, because you have studied the Strowger system and the XY linefinder and selector, which function in a similar manner and require similar procedures. Keeping the relays and switches clean is the most important single task for keeping the switching equipment operating properly. Dust on these components not only prevents the relays from functioning and the switches from stepping, but it also causes circuit deterioration. To maintain these units, use the applicable preventive maintenance workcard set.

To locate the sample connector trouble we are providing, we emphasize use of systematic procedures. Of course, what each of you use in doing the exercises may vary from what is used in our preliminary sample.

630. Given a representative XY telephone equipment trouble symptom, use the connector diagrams in this chapter as necessary to determine and identify probable trouble(s) and some proper corrective procedures.

Several subscribers have reported they had difficulty holding a conversation because of noise. We know now that one connector may have served each of these subscribers. Furthermore, they probably made other satisfactory calls which were completed by other connectors. You could ask each of them for this additional information, but there is no reason for delaying the further testing which is required. What are you checking for? Noisy transmission is usually caused by poor connections—cords, jumpers, wires or contacts. And since we are concerned with inside plant, the probable trouble is linefinder relay or switch contacts, selector relay or switch contacts, or connector relay or switch contacts. Of course, for this trouble we are limiting it to a connector in the group of connectors that serve these particular subscribers. You will inspect and test each connector in the group and look for poor connections. Looking at text figure 3-3, you should recognize that the contacts to inspect include 2 and 3 and 5 and 6 of relay AB, 4 and 5 and 7 and 8 and 23 and 24 of relay SW and the tip and ring wipers.

Exercises (630):

Use the text information and applicable diagram to determine probable troubles for the listed trouble symptoms. Give an appropriate action for eliminating each symptom.

1. Called telephone doesn't ring.

2. Connector fails to trip ringing.

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CHAPTER 4

Alarm, Supervisory, Power and Ringing Equipment

YOU HAVE studied the Automatic Electric circuits on alarms, supervisory, power and ringing equipment. The XY circuits are very similar to and function in the same manner as do the AE circuits. The XY central office equipment is furnished with numerous alarm and supervisory circuits to indicate any abnormal conditions that may occur. The alarm and supervisory circuits are designed to alert you with an audible and/or visual signal, the type of fault and its general location in the equipment. The power equipment provides the meters. These indicate the charge and discharge current of the office battery, the office voltage and circuit breakers in the main charge and discharge circuits. The ringing equipment is designed to generate ringing and tone voltages. The interruption of these voltages and the development of the various pulses necessary for the operation of the exchange is accomplished by the motor driven interrupter machine. It is obvious that a good understanding of the alarm, supervisory, power and ringing equipment is essential in your job.

4-1. Purpose of Alarm and Supervisory Circuits

This section attempts to explain the alarm and supervisory circuits used in an XY central office.

631. Concerning general alarm and supervisory equipment conditions, list two classes of alarm conditions, and the audible alarm for various typical conditions, give the locations of group and two signals for alarm and common supervisory equipment, and identify the visual signal color when a heat coil blows. Also, name that for which common supervisory equipment is the termination point. Give the location of that equipment.

General Requirements for Alarm and Supervisory Equipment. The first requirement for an alarm system is to identify and indicate the class of equipment alarm. In the XY equipment it is either "emergency" or "nonemergency." The emergency class of alarm is, as the name implies, an emergency condition in the equipment, and corrective action must be immediate and positive. The emergency alarm is identified by a bell, buzzer, and red lamps. The second class of alarm is the nonemergency. Again, the term implies that a malfunction has occurred; but it should not impair the functions of the office. However, this class of alarm should also be cleared immediately. The nonemergency alarm is identified by a buzzer and white, green or red lamps. These two classes of alarms are similar to the major and minor alarms you studied in the Strowger step-by-step office.

The second requirement is to identify the location of the equipment that has the abnormal condition. This is called the supervisory circuit and is made up of group, row and shelf supervisory equipment. When a malfunction occurs in the equipment, the supervisory circuits control the lamps that direct the maintenance person to the shelf of equipment that is in trouble. These lamps are located on the various components of equipment throughout the central office. The first set of lamps to be considered are located at the top of the powerboard, in the group supervisory panel. The number of sets of lamps will indicate the size of the office. There is one set of lamps per 1000 group of lines, with three lamps for each group of equipment, as follows:

- Equipment alarm (Green).
- Fuse alarm (Red).
- LF Start (Clear).

The next set of lamps are the row supervisory lamps. These are located on the end of a row of bays and are red lamps indicating which side of the row the malfunction is on—either right or left. Each shelf has a supervisory circuit plate and a fuse panel, with the lamps mounted in each, to indicate the malfunctioning equipment.

We have discussed briefly the group, row and shelf supervisory circuits. These circuits are under the control of the common supervisory circuit. The common supervisory equipment serves as a termination point for alarm indications from the XY dial switching equipment, powerboard, relay racks, attendants' switchboard, and the main distributing frame. The common supervisory panel is mounted in the powerboard.

Alarm Conditions. The following is a list of emergency and nonemergency alarm conditions and the visual indications the maintenance person will receive:

Class of Alarm	*Alarm Condition*	*Alarm Delay Times*	*Visual Signal*
Emergency	Common Fuse	0	Red Lamp
	Low Voltage	0	Red Lamp
	Allotter Start	2-4 min	Red Lamp
Nonemergency	Equipment Release	3-9 sec	Green Lamp
	Individual Fuse	0	Red Lamp
	Heat Coil	0	Clear Lamp

Exercises (631):

1. Name the two classes of alarms.

2. State the two signals which identify alarm conditions.

3. Where is the group supervisory equipment located?

4. When a heat coil blows, what color will the visual signal be?

5. Where is the common supervisory equipment located?

6. List in minutes or seconds, the length of time used to bring in an audible alarm for the following conditions:

   a. A allotter fuse blows.

   b. Linefinder fuse blows.

   c. Selector fails to release.

   d. Heat coil blows.

   e. B allotter fails.

7. The common supervisory equipment is the termination point for what?

8. Give the location of the common supervisory equipment.

4-2. Alarm and Supervisory Circuit Operation

The following is an explanation of the alarm and supervisory circuit operations.

632. Using foldout 4's common supervisory circuits schematic diagram as required, identify the common equipment controlled by that circuit.

Common Equipment Start. The common supervisory circuit provides a common starting point for the interrupter circuit, ringing control circuit and tone generator circuit. When there is no demand for service on the central office, the interrupter, ringing, and tone circuits are off. However, in larger offices these circuits are in operation continuously. When any demand for service is initiated, a ground is extended from that particular circuit to the common control on the ST or ST1 Leads.

Demand for service. When a subscriber goes off-hook, the SA and day in the allotter, shown on foldout 4, (found in a separate inclosure), chooses a ground to the ST lead through contacts 1 and 2. This happens when:

a. Relay ST operates. Contacts 1 and 2 close the hold circuit to itself on the H2 lead, which has ground on it, except for about 6 seconds out of every 2 minutes.

Contacts 3 and 4 close the ground to the interrupter circuit.

Contacts 5 and 6 start the subcycle for ringing.

Contacts 7 and 8 close the circuit to the tone generator.

This condition will continue until the demand has been removed. This may be caused by the call being completed or the subscriber's having hung up. When either or both happen, the ST relay stays operated until the ground is removed by the H2 cam on the interrupter, which causes ST to release.

b. Relay ST releases. Contacts 1 and 2 open the hold circuit.

Contacts 3 and 4 shut down the interrupter.

Contacts 5 and 6 open the ringing machine circuit.

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Exercise (632):

1. Name the common equipment that is controlled by the common supervisory circuit.

633. Using foldouts 3, 4, and 5's common, shelf, bay and group supervisory schematic diagrams as required, identify the equipment operated for the specified alarms by listing the indications or relays involved; stating what determines a common fuse, how to determine fuse location in a row of equipment, an operator's action at night when a low-voltage alarm occurs, the voltages on which the BV relay in the common supervisory circuit holds and releases, the classes of alarm produced by a heat coil failure or an individual fuse failure, and the supervisory equipment required for an emergency alarm condition; and giving the purposes of the low-voltage alarm and the release alarm.

Common Fuse Failure. A fuse that furnishes current to more than one circuit is classified as a "common" fuse. The line circuit in a linefinder shelf has a common fuse. If one of these fuses blows, twenty circuits become inoperative; thus, classifying it as an emergency fuse.

When a common fuse blows, see foldouts 4 and 5, found in a separate inclosure, in a Linefinder Shelf, negative battery from the battery distribution circuit would flow through the blown fuse, the EM fuse alarm lamp and out the EFA lead to the Row Supervisory Equipment (FO 4,) through the lower windings of the C or D relay, out the EFA lead to the Common Supervisory Circuit (FO 5) through the ca winding of relay EF to ground at punching 49. This follows:

Relay C or D operates. If the fuse is inoperative on the left side of the bay, relay C operates, closing its contacts 1 and 2 to complete a circuit for the row pilot lamp on the left side of the bay.

Relay EF operates. Contacts 1 and 2 close a circuit to the fuse lamp on the common supervisory panel. Contacts 3 and 4 close a circuit to relay E.

Relay E operates. Contacts 1 and 2 is associated with figure 10. Automatic Audible alarm cutoff is not used in the USAF XY exchanges; therefore it will not be discussed.

Contacts 3 and 4 close a circuit to the emergency alarm lamp and bell (FO 4, fig. 2) in the extension alarm located on the switchboard.

Contacts 6 and 7 close a circuit to the buzzer (normally this is a bell, because it is an emergency alarm) that signals the maintenance person.

If the maintenance person desires to silence the alarm until the fuse is replaced, he operates the alarm cut-off key. The operation of the alarm cut-off by the maintenance personnel (FO 4, fig. 1) or the switchboard operator (same foldout, fig. 2) gives a path for relay CO to operate.

Relay CO operates. Contacts 1 and 2 open the circuit to the bells in the extension alarm (FO 4, fig. 2).

Contacts 3 and 4 open the circuit to the buzzer in the exchange.

Contacts 4 and 5 give the CO a holding circuit when the defective fuse is removed it opens the circuit to relay C or D and relay EF.

Relay C or D releases. Contacts 1 and 2 open the circuit for the row pilot lamp.

Relay EF releases. Contacts 1 and 2 open the circuit to the fuse lamp on the common supervisory panel.

Contacts 3 and 4 open the circuit to relay E.

Relay E releases. Contacts 3 and 4 open, removing the ground from the EM alarm lead going to the extension alarm, causing the emergency red lamp to go out.

Contacts 6 and 7 open, breaking the hold circuit for relay CO.

Low-Voltage Alarm—Common Supervisory Circuit. This discussion covers a low-voltage condition and the extension alarm. The LV relay monitors the exchange battery voltage continuously. This relay is adjusted to release on 45.5 volts and to hold operated on 46.5 volts. Its operating path is from negative battery at the contacts of the CAL switch, through the ac winding of relay LV, resistor R-2, potentiometer P-1, and resistor R-1 to ground. When the voltage drops below 45.5 volts, the LV relay releases. At this point:

Relay LV releases. Contacts 1 and 2 close a circuit to relay VB.

Relay VB operates. Contacts 1 and 2 close a circuit to the low-voltage alarm lamp on the supervisory panel.

Contacts 3 and 4 open the circuit to the slow-to-operate VA relay. The slow-to-operate feature also makes it slow-to-release.

Contacts 4 and 5 close a circuit to relay E.

Relay E operates. Contacts 3 and 4 close a circuit to the emergency alarm lamp and bells (FO 4, fig. 2) in the extension alarm located on the switchboard.

Contacts 6 and 7 close a circuit to the buzzer located in the frame room.

If the trouble occurs on the night shift or anytime when there are no maintenance personnel on duty, the switchboard operator pushes the nonlocking cutoff key to silence the bell. She notifies the responsible personnel of the condition. The operation of the cutoff key gives relay CO an operate path.

Relay CO operates. Contacts 1 and 2 open the TAL lead making the bells in the extension alarm inoperative.

Contacts 3 and 4 open the circuit to the buzzer in the exchange.

Contacts 4 and 5 give the CO relay a hold circuit to contacts 6 and 7 of relay E.

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While the operator is accomplishing all of this, relays in the exchange continue to operate and release. When we left relay VA, it was on slow to release.

Relay VA releases. Contacts 1 and 2 close giving relay E an alternate ground which it will need later.

Contacts 3 and 4 close a circuit to relay LV shunting resistor R-1 and the potentiometer P-1.

Relay LV operates. Contacts 1 and 2 open the circuit to relay VB and it goes on slow to release.

Relay VB releases. Contacts 1 and 2 open the circuit to the low-voltage alarm lamp.

Contacts 4 and 5 open the original operate circuit to relay E, but it remains operated from a ground at contacts 1 and 2 of relay VA which is released.

Contacts 3 and 4 close a circuit to the slow-to-operate VA.

Relay VA operates. Contacts 1 and 2 open the circuit to the slow-to-release E.

Contacts 3 and 4 open the shunt circuit that was on relay LV.

If the voltage has increased to above 45.5 volts, the LV relay will remain operated. If the voltage has NOT increased, the LV relay would release closing a circuit to relay VB. Relay VB reoperates before the slow-to-release time is depleted on relay E. Thus, the alarm signals stay on until the trouble is cleared. During a low-voltage condition relays LV, VA, and VB will continue to pulse. The alarm sounds continuously, unless cut off, and the low-voltage lamp flashes.

Release Alarm (Delay Alarm). When a release magnet operates and the switch mechanically fails to return to normal, a ground is on the RA lead in the Shelf Supervisory Circuit S-50275, seen in foldout 5, figure 2-2A or 3, depending on which switch failed. The RA relay in one of the figures would operate. This then occurs:

Relay RA operates. Contacts 3 and 4 place a ground on the PC lead to operate the peg count meter.

Contacts 1 and 2 close the circuit through the RLS (release) lamp, out the DA lead to the Common Supervisory Circuit, through contacts 5 and 6 and the CA winding of the DA relay.

Relays DA operates. Contacts 5 and 6 close the circuit to the interrupter.

Contacts 3 and 4 prepare a hold circuit to DB.

Contacts 1 and 2 connect the PU lead to the DB relay.

When the PU pulse arrives, sometime in the next 3 seconds, DB operates.

Relay DB operates. Contacts 1 and 2 complete the holding circuit.

Contacts 3 and 4 connect the ECP lead to the DC relay.

When the ECP pulse arrives, sometime in the next 6 seconds, DC operates.

Relay DC operates. Contacts 5 and 7 close a hold circuit to ground on the DA lead.

Contacts 5 and 6 open the circuit to relay DA.

Contacts 1 and 2 light the equipment release lamp.

Contacts 3 and 4 place a ground on the NEM lead to the switchboard and the buzzer.

Relay DA releases. Contacts 1 and 2 open the operate circuit to DB.

Contacts 3 and 4 open the hold circuit to DB.

Contacts 5 and 6 open the circuit to the interrupter.

Relay DB releases. Contacts 1 and 2 open the lock path to itself.

Contacts 3 and 4 open the ECP lead.

The DC relay will remain operated until the switch has been released. This will remove the ground off of the DA lead.

Relay DC releases. Contacts 5 and 7 open the lock circuit to itself.

Contacts 6 and 5 connect the DA lead to the DA relay.

Contacts 1 and 2 open the circuit to the green lamp on the power board.

Contacts 3 and 4 open the circuit to the white lamp on the switchboard and the buzzer.

The release alarm is now back to normal. Notice a delay of 0 to 3 seconds for DB to operate and a delay of 3 to 6 seconds for DC to operate. The audible alarm sounds sometime between 3 and 9 seconds.

Nonemergency Fuse Alarm. Use figure 1 in the shelf supervisory circuits, foldout 5, as you proceed here. Assume that one fuse fails. Battery is sent through the broken fuse and the red lamp to the FA lead through the F relay in the Common Supervisory circuit to the ground.

Relay F operates. Contacts 1 and 2 place a ground on the red lamp in the power board.

Contacts 3 and 4 place a ground on the NEM lead to the attendant's cabinet and the buzzer.

When the fuse is cleared, relay F releases and turns off the lamps and the buzzer.

Emergency Fuse Alarm. Use foldout 5, figure 13, in the shelf supervisory circuit as you proceed here. Assume that one fuse fails placing a battery on the EFA lead to the Common Supervisory circuit causing relay EF to operate. This happens:

Relay EF operates. Contacts 1 and 2 close the circuit to the fuse lamp.

Contacts 3 and 4 close the circuit to relay E.

Contacts 6 and 7 send ground through the buzzer.

Relay E operates. Contacts 3 and 4 place a ground on the EM ALM and TAL leads to the Alarm Send Circuit.

When the broken fuse is removed, the fuse lamp in the shelf supervisory circuit will go out, and EF relay in the common supervisory circuit will release. This will release relay E and eliminate the remaining audible and visual alarms.

Heat Coil. When a heat coil becomes defective, it places a ground on punching 15 of the common supervisory circuit and gives the HC relay an operate path. The circuit recognizes this as an emergency alarm, although it is a nonemergency condition. Therefore:

Relay HC operates. Contacts 1 and 2 close a circuit to the heat coil lamp on the common supervisory panel.

Relay E operates. Contacts 3 and 4 close a circuit to the emergency alarm lamp bells (FO 4, fig. 2) in the extension alarm.

Contacts 6 and 7 close a circuit to the buzzer to signal the maintenance personnel.

When the heat coil is restored or replaced, the ground is removed from punching 15, opening the circuit to relay HC.

Relay HC releases. Contacts 1 and 2 open the circuit to the lamp on the supervisory panel.

Relay E releases. Contacts 6 and 7 open the circuit to the buzzer.

Emergency Start Fail. Assume that twelve of the finders in a given shelf are busy and that the two remaining finders will not hunt because of mechanical failure. The SA relay in the allotter operates, and its contacts 3 and 4 place a ground on the EM Fail lead via the EM ST FAIL lamp. This ground is sent to the common supervisory circuit and to the SA relay. At this point:

Relay SA operates. Contacts 3 and 4 connect the SB relay to the Time Pulse One lead.

Contacts 1 and 2 partially complete a hold path to SB.

Within the next 2 minutes a ground will appear on the TPI lead causing the SB relay to operate.

Relay SB operates. Contacts 3 and 5 close the hold path.

Contacts 3 and 4 open the original operate path.

Contacts 1 and 2 connect relay SC to the TP2 lead.

A ground will appear on the TP2 lead in 1 minute and 54 seconds, causing SC to operate.

Relay SC operates. Contacts 3 and 4 start the emergency alarm sequence.

Contacts 5 and 7 hold the SC relay to the ground being supplied by the SA relay in the allotter.

Contacts 5 and 6 open the circuit SA.

Contacts 1 and 2 light LF ST FAIL lamp.

Relay SA releases. Contacts 3 and 4 open the TPI lead.

Contacts 1 and 2 open the lock path to SB.

Relay SB releases. Has no effect at this time. We have used TPI and TP2 time, which could amount to about 4 minutes, to bring in the emergency start bail alarm. Meanwhile, the working allotter will continue to search for a idle linefinder. If one of the twelve busy linefinders becomes idle, the demand for service will be processed and will cause SC relay to release. It is also possible to remove the alarm by replacing the two faulty switches.

When the two bad switches have been replaced, and the out of service allotter has been transferred back into service, one of them finds the line. SA in the allotter releases, removing the ground from the EM ST FAIL lead and causing SC to release.

Relay SC releases. Contacts 3 and 4 remove the ground from the EM lead.

Contacts 6, 5, and 7 prepare the circuit for the next alarm.

Common Supervisory Fuse Failure. When the *ground fuse* in this circuit fails, a ground is extended through the blown fuse and the E relay, causing the same alarms as for the low-voltage alarm.

When the *battery fuse* fails in this circuit it completes a circuit to the EF relay through resistor R4.

Relay EF operates. Contacts 1 and 2 close the circuit to the fuse lamp.

Contacts 3 and 4 close the circuit to the E relay, starting on emergency alarm as already described.

Timing Start. Any circuit that will apply ground on the ST1 lead needs timed ground pulses and various tones. When a ground is placed on the ST1 lead, the ST1 relay will operate.

ST1 Relay operates. Contacts 3 and 4 start the interrupter circuit.

Contacts 2 and 1 lock ST1 to the H2 lead.

Contacts 5 and 6 start the tone generator.

Normally the tone generator and the ringing generator operate continuously, thus nullifying the contacts of ST and ST1, which are associated with these two generators.

Figures 6 and 9, foldout 5, are not used in military offices. Briefly the function of these figures is to sound an alarm on a permanent signal after a 30-minute delay.

Figure 7, foldout 5, is used on toll equipment for commercial purposes.

Figure 8, foldout 5, is used on alarms for circuits associated with toll restriction adapter, or overloaded converters. These alarms are not normally used in a military office.

Exercises (633):

1. What determines a common fuse as compared to an individual fuse?

2. When a fuse fails in a row of equipment, how does the maintenance man determine the location of the fuse?

3. What is the purpose of the low-voltage alarm?

4. What is the purpose of the release alarm?

5. List the visual indications for a nonemergency fuse alarm.

6. List the visual indications for a emergency fuse alarm.

7. What does the switchboard operator do when there is a low-voltage alarm at night?

8. List the relays that operate when the alarm cut-off key is operated.

9. List the alarm indications when a switch fails to step.

10. The LV relay in the common supervisory circuit will
    a. Hold on _________ volts.
    b. Release on _________ volts.

11. List the relays that pulse during a low-voltage condition.

12. What class of alarm will a heat coil failure produce?

13. What class of alarm will a individual fuse failure produce?

14. What supervisory equipment is involved in a emergency alarm condition?

4-3. Troubleshooting

You have been through troubleshooting in previous lessons. Thus there seems little need to discuss the procedures at this time. However, a thought at this time may be appropriate. Your whole career has been directed along the lines of keeping the telephone equipment in good repair. This is the area where you "make your money." Use the established procedures and perform them in a safe manner. This will also make your job easier.

634. Given representative alarm and supervisory equipment trouble symptoms, using foldouts 3, 4, and 5's schematic diagrams as necessary, determine the probable causes and the proper corrective actions needed in each situation.

Exercises (634):

1. Many alarm conditions have been experienced, however, there has been no lamp indications and the buzzer has not sounded in the common supervisory panel. What could be the possible cause? How would you correct it?

2. All of the alarm lamps function, but the buzzer will not indicate emergency or nonemergency alarms. What is the cause and how would you fix it?

3. The low-voltage alarm is on, and the voltmeter indicate the office battery voltage is 52 volts. What are the possible causes and corrective actions?

4. A shelf of selectors has initiated a delayed release alarm. The switch in the selector will not release, and there is no audible alarm. Relay DA in the common supervisory circuit is operated. Relay DB operates and releases every 3 seconds. What is causing this and how would you fix it?

5. The 1$^{1}/_{3}$ amp battery fuse in the common supervisory circuit fails, removing battery from the alarm lamps. But the red fuse lamp, relay E and the buzzer are all operating. How is the battery supplied and from what source?

6. During an emergency start fail alarm, the SA and SB relays operate, and the audible and visual alarms never come on. What is the possible trouble? How would you fix it?

7. In a small office, the interrupter runs continuously. Delays ST and ST1 are released. What could cause this malfunction? What is the corrective action?

4-4. Purpose of Power and Ringing Equipment

You have studied the batteries and changing equipment earlier in this course. The power devices used in XY offices are the same ones as those that are used in Strowger or any other telephone office. We will therefore only discuss the circuits that are applicable to XY central offices here.

635. State the purpose and the functions of each of the power and ringing circuits. Consult foldouts 6, 7, and 8 as necessary.

Discharge and Distribution. The purpose of the discharge and distribution circuits, shown in foldout 6, is to supply main battery voltage through the circuit breaks to the exchange equipment. The functions of the circuit are these: to indicate the excharge voltage, to indicate the current charge or discharge to the exchange, to provide direct ground to the equipment protected by a circuit breaker, to send voltage to the common supervisory circuit for calibration purposes, and to indicate overload and short conditions.

Ringing Control. The purpose of the ringing control, shown in foldout 7, is to supply fused ringing current to the exchange equipment. The functions are: to operate the subcycle continuously with automatic transfer to the ringing machine in case of output failure, to furnish audible and visual alarms upon failure, and to provide manual controls for transfer.

Interrupter Circuit. The purpose of the interrupter, shown in foldout 8 and found in a separate inclosure, is to supply interrupted ringing and timed ground pulses to control the exchange equipment. The functions are to start the ac interrupter when needed, to transfer to the dc interrupter in case of ac failure, and to supply interrupted ringing and ground pulses.

Exercises (635):

Give the purpose and functions of each of the following:

1. Discharge and distribution.

2. Ringing control.

3. Interrupter circuit.

4-5. Power and Ringing Circuit Operations

We will now examine thoroughly the operation of the power and the ringing circuits.

636. Using foldouts 6, 7, and 8's schematic diagrams of the power and ringing circuits as necessary and involving that equipment operating when a demand for services occurs, identify how the alarm system gets operating power if all main circuit breakers trip, voltmeter reading when the calibrate key operates, what indicates circuit breaker tripping, what causes RM machines to transfer to subcycle, and the subcycle's voltage output. Also indicate the current type the discharge and distributing circuit reveals, give purposes of the discharge and distribution circuit's rheostat and the ringing control circuit. Briefly explain why the latter circuit has two ringing machines.

Discharge and Distribution. Figure 1 of foldout 6 shows the connection between the flotrols, main battery, and the powerboard (FO 6, fig. 3). In figure 3 one side of the voltmeter is connected through a 3-amp fuse to ground. The other side is connected through the normal contacts of the battery volts and calibrate keys, powerboard breaker and the ammeter to the main battery. This circuit will give a continual reading of the exchange voltage.

The ammeter is connected in series with equipment circuit breakers and the negative main battery. The ammeter will read either the current which is charging the main battery or the current the main battery is supplying to the equipment. The ammeter is a zero center meter, and the directions of deflection indicates the charge or discharge.

Exchange ground is connected from the chargers and main battery thru the main circuit breaker to the equipment. Earth ground is also connected directly to the equipment. The power for the alarms is fed thru R-3 and R-4 to the equipment. In the event any or all equipment breakers trip, the alarm circuits are assured power for operation.

The calibration key and the rheostat enable the installer and maintenance man to adjust the voltage on the − CAL lead to the common supervisory circuit. The voltmeter will indicate the voltage sent out on the − CAL lead. R-1 rheostat adjusts the circuit to the desired voltage. By operating the CAL key on the discharge and distribution panel and the CAL LV key on the common supervisory panel, the low-voltage alarm may be tested.

When a circuit breaker trips due to a short or overload, it will remove the negative battery from the associated equipment. The tripped breaker will also apply battery thru the breaker alarm lamp, out the EMF (emergency fuse alarm) lead to the common supervisory circuit.

Figure 5, foldout 6, is used when negative battery is distributed to equipment in more than one group.

Figure 7, foldout 6, shows a low-voltage alarm which was covered in the common supervisory circuit.

Figure 6, foldout 6, is day battery associated with an unattended switchboard. It is used in conjunction with the trunk circuits. When the operator leaves the position, the cords are used to patch the trunks to a predetermined subset that will be manned at all times.

Figure 2, foldout 6, shows the connection of the counter cell.

Ringing Control Circuit. The ringing circuit controls the output from the ringing machines. The subcycle, shown in Figure A of foldout 7, will run continuously when there is an ac source for the exchange. Upon failure of the subcycle, a dc ringing machine, shown in Figure B of this foldout, is started. At the same time, an alarm will be activated to indicate a transfer for one machine to the other. These ringing sources furnish the XY Central Office with ringing current.

The subcycle is operated by 110V ac source and generates 90 volt 20 cycle ringing current which operates relays G1 and G2. The purpose of the RF-1 and RF-2 along with R1 and R2 is to prevent the G1 and G2 from chattering on the AC current. Therefore:

1. Relay G1 operates. Contacts 1 and 2 open the nonemergency alarm (NEM) lead to prevent an alarm.

Contacts 4 and 5 open, preventing the TR relay from operating and thus preventing a transfer to the DC ringing machine.

2. Relay G2 operates. Contacts 1 and 2 open the emergency (EM) lead, preventing an alarm while the relay is functioning properly.

Contacts 4 and 5 open the ground to the GEN FAIL lamp to prevent it from lighting.

Relays G1 and G2 are normally operated and ringing current is supplied to the generator bus bar. From the generator bus bar it is distributed to the required circuits. Should the subcycle fail to produce ringing current, the G1 and G2 relays will release.

1. Relay G1 releases. Contacts 1 and 2 complete a path to the NEM lead and this brings in a nonemergency alarm.

Contacts 4 and 5 complete a path to the TR relay. They also place a ground on the RM ST lead to foldout 7, figure B. This ground operates the RM ST relay in foldout 7, figure B.

2. Relay G2 releases. Contacts 2 and 1 close a path to the EM lead.

Contacts 5 and 4 close the path for the GEN FAIL lamp.

When the TR relay operates, it establishes a path for the DC ringing machine to supply ringing current to the G2 relay and the bus bar.

3. Relay TR operates. Contacts 1 and 2 close the path for the GEN TRANS lamp and it will light.

Contacts 4 and 3 and 7 and 6 open the path from the subcycle.

Contacts 5 and 4 and 8 and 7 close a path to reoperate the G2 relay.

4. RM ST relay operates. The contacts of the RM ST relay close a circuit to start the DC ringing machine.

The DC ringing machine is started. When its output is of sufficient strength, the G2 relay will reoperate. The path for reoperation of the G2 relay is through contacts 5 and 4 and 8 and 7 of the TR relay.

5. Relay G2 operates. Contacts 1 and 2 open the EM lead.

Contacts 4 and 5 remove the ground from the GEN FAIL lamp.

The output of the DC ringing machine is now to the generator bus bar. The circuit will remain in this state until something is done to repair or restart the subcycle. When the subcycle is restarted, the G1 relay will reoperate. Here, then:

1. Relay G1 operates. Contacts 1 and 2 remove the ground from the NEM lead and removes the alarm.

Contacts 5 and 4 open the circuit of the TR relay.

Contacts 5 and 4 also remove the ground from RM ST lead and release the RM ST relay.

2. Relay TR releases. Contacts 8 and 7 and 4 and 5 open, contacts 4 and 3 and 7 and 6 make thereby changing the output to the Centrol Office from the DC machine to the subcycle.

3. Relay RM ST releases. This opens the circuit of the ringing machine starter, and its output will now cease.

During this transfer, the G2 relay may or may not have released. Had it released, there would have been an alarm. But it would have been of such short duration that no one would probably have noticed it.

Manual control keys. There are two keys associated with this circuit: (1) GEN TRNS and (2) RM ST. With these keys, it is possible to accomplish manually what has already been explained as occurring electrically.

Fuse alarm. Should any fuse of the ringing control circuit blow, there will be an operating path for the FA relay. Through the contacts of the FA relay a circuit will be completed to the common supervisory circuit, and an audible alarm will be sounded.

The generator bus bar has seven fuses, one of which is labeled MISC. It furnishes continuous generator to the necessary equipment, such as test desk, attendant's cabinet, reverting call switches, etc. The remaining six fuses furnish ringing circuit to the two interrupters, three for each.

Interrupter Circuit. The purpose of the interrupter circuit, shown in foldout 8, is to supply interrupted ringing and ground pulses to the necessary circuits. The interrupter springs are operated by either an ac or dc motor equipped with gears and cams. Under normal conditions the ac motor and cams supply the interruptions. The dc motor and cams are used for backup when the ac interrupter fail. The ac interrupter circuit is started by a ground being received from the common supervisory circuit. This ground comes through the INT ST lead at punching K-34. Follow it through the INT TRANS key, the L relay and the MOT REL fuse to battery. This operates the L relay and closes the circuit to the ac interrupter motor. When the motor starts turning, the cam starts opening and closing the snap action switches, which are shown in foldout 6's figures 5, 6, 7, 8, and 9. This then follows:

Relay B operates. The B relay operates from ground on the INT ST lead.

Contacts 1 and 2 close a circuit to the C relay and prepares a path for the D relay.

Relay C operates. Contacts 1 and 2 close the operating circuit to the D relay.

Relay D operates. Contacts 1 and 2 further open the NEM lead to prevent an alarm when the A relay operates.

Contacts 3 and 4 further open the circuit to the F relay.

Contacts 4 and 5 completes the path to the A relay.

Relay A operates. Contacts 1 and 2 prepare the nonemergency alarm path.

Contacts 3 and 4 prepare a path for F relay.

Contacts 7 and 5 close before 5 and 6 break in order to hold the A relay operated over the INT ST lead.

Contacts 21 and 22 open the operating path for the C relay and places it on slow to release.

Contacts 22 and 23 prepare an alternate path for the C relay.

Contacts 24 and 25 open the operating path for the B relay.

Contacts 25 and 26 prepare an alternate path for the B relay.

When the motor is running the cams are making and breaking the snap action switches. One complete revolution of the cam shaft is once every 6 seconds. However, some of the cam wheels have more than one lobe. Cam wheel number 5 has sufficient lobes to operate the springs at the rate of 120 IPM. This ground interrupted at 120 times per minute has several function, one of which keeps the B and C relays operated. As long as this machine is putting out 120 IPM there will be no automatic transfer to the dc interrupter.

Concerning the output of cams. Cam wheel number 7 causes ground to be interrupted at the rate of 60 IPM which is used for connector busy tone operation.

Cam wheel number 9 causes ground to be interrupted 30 times per minute for one tick tone, which the military doesn't use.

Cam wheel number 11 causes ground to be interrupted at the rate of 10 IPM, which is used for timing circuits.

Cam wheel number 13 places ground on the PU leads of the linefinder and supervisory circuit.

Cam wheel number 15 places ground to the circuits that require the REV GND feature.

Cams numbered 2, 4, 6, 8, 10, and 12 make and break the paths for generator and trip battery. Generator (ringing current) is furnished through the springs at the rate of one second ring and a five second pause. Trip battery is furnished when ringing current is off. Cams 4, 6, 8, 10, and 12 are not used in small offices or by the military exchanges.

Figure 6 of foldout 8 shows the timing chart for the 2 minute cycle. This portion of the interruptor is on the left hand side and uses a gear linkage to reduce the 6 sec revolution to a 2 minute revolution. Cams 23 and 24 furnishes timing pulse 1 and 2 to the alarm circuit. Cam 26, the H2 lead, is used for holding the ST or ST1 relays in the common supervisory circuit, which keeps the tone and interrupter circuits operating. All of the cam spring contacts are routed through figure 2 or 10 of foldout 8 to the appropriate equipment. H3 and RVT are not used in military exchanges.

Transfers.-Transfers may occur in two ways—either manually or automatically. Let us cover the automatic transfer first. If for some reason the cams on the ac machine stopped putting out the 120 IPM ground that is holding the B and C relays, then the B or C would release. When B or C released, it would open the path to the D relay, allowing it to release. Thereafter:

Relay D releases. Contacts 1 and 2 close the NEM lead to the supervisory circuit which sounds an alarm.

Contacts 3 and 4 complete a path to the F relay.

Relay F operates. Contacts 1 and 2 close a circuit to the INT TRANS lamp.

Contacts 25 and 26 close a circuit to the INT ST2 lead, to start the DC motor in figure 1, foldout 8. They also place a ground on the B relay, shown in figure 1 foldout 8, to operate it.

Contacts 3 and 4 complete a circuit to operate the G and E relays.

Contacts 21, 22, and 23 and 5, 6, and 7 transfer the H2 and REV GRD leads from the ac to the dc interrupter contacts.

Relays G and E operate. The contacts of the G and E relays transfer all of the ac interrupter contacts' output to the control of the dc interrupter contacts.

Relay B operates (FO 8, fig. 1). Contacts 1 and 2 close the operating path of the C relay.

Relay C operates. Contacts 1 and 2 close the operating path to the D relay.

Relay D operates. Contacts 1 and 2 further open the path to the EM lead. Contacts 4 and 5 close the path to the A relay.

Relay A operates. Contacts 1 and 2 prepare the path to the EM lead.

Contacts 3 and 4 prepare the path to the INT FAIL lamp.

Contacts 5 and 7 close before 5 and 6 open to place a holding path on the A relay.

Contacts 25 and 26 and 22 and 23 transfer the control of the B and C relay of figure 1, foldout 8, to the 120 IPM lead on the dc interrupter.

The circuit will stay in this state until ground is removed from the INT ST lead, the INT TRANS key is operated, or the dc interrupter fails to put out the 120 IPM ground to the B and C relays.

No Demand. Let us now assume that there is no longer a demand for any of the interrupter services and that ground is removed from the INT ST lead. This opens the circuit to the L relay and causes it to release. Remember, the dc interrupter is providing the impulse for the exchange, but the L relay (fig. 2 or 10 of FO 8) would still have an operating path. The A, F, E, and G of figure 2 or 10 would still be operated. They would be the first relays to release when the interrupter service is no longer needed.

Relay A releases (fig. 2 or 10, FO 8). The A relay upon release performs the following functions.

Contacts 1 and 2 open the NEM lead and extinguish the alarm.

Contacts 3 and 4 further open the circuit to the F relay.

Contacts 5 and 6 prepare the circuit for the A relay.

Contacts 5 and 7 open the holding path of the A relay.

Contacts 21 and 22 prepare the circuit for the C relay.

Contacts 24 and 25 prepare the circuit for the B relay.

Relay F releases. The relase of the F relay causes the following action:

Contacts 1 and 2 extinguish the INT TRANS lamp.

Contacts 3 and 4 open the circuit to the E and G relay, causing them to release.

Contacts 21 and 22 and 5 and 6 return the REV GRD and H2 lead to the control of the ac interrupter.

Contacts 25 and 26 open the INT ST2 lead and open the circuit to the dc interrupter motor and the A relay in figure 1 of foldout 6.

Relays E and G release. When the E and G relays release, this transfers the outputs of the dc interrupter cams back to the outputs of the cams of the ac interrupter.

Relay A releases (fig. 1, FO 6). Contacts 1 and 2 further open the EM lead.

Contacts 3 and 4 further open the INT FAIL lead.

Contacts 7 and 5 further open the holding path of the A relay.

Contacts 5 and 6 prepare the circuit to reoperate the A relay.

Contacts 25 and 26 open the circuit to the B relay.

Contacts 24 and 25 prepare the operating path for the B relay.

Contacts 22 and 23 open the circuit for the C relay.

Contacts 21 and 22 prepare the operating path for the C relay.

Relay B or C releases. Only the B or C would have been operated due to the 120 IPM ground.

Contacts 1 and 2 open the circuit to the D relay, allowing it to release.

The circuit is back to its normally unoperated condition and will remain so, until another requirement is demanded.

When making a manual transfer it is necessary to operate the INT TRANS key. Then, when the ground is placed on the INT ST lead, the F relay will operate. The F relay will, in turn, operate the E and G relays. The E and G relays will transfer the contacts from control of the AC machine to the control of the DC machine. The remainder of the transfer occurs just as we have explained when discussing automatic transfer.

The interrupter can be run constantly by the use of the INT ST keys. These keys could also be used just to test the operation of the interrupters. This is the usual procedure in a large busy exchange.

Exercises (636):

1. Does the ammeter in the discharge and distribution circuit indicate charge current or discharge current? Explain briefly.
2. If all of the main circuit breakers trip, how will the alarm system receive the power to operate?
3. What will the voltmeter read if the calibrate key is operated?
4. What will indicate that a circuit breaker has tripped?
5. What is the purpose of the rheostat in the discharge and distribution circuit?
6. What is the purpose of the RFI and resistor R1 in the ringing control circuit?
7. If the subcycle and the RM machine fail, what type of alarm would be set off?
8. Why are there two ringing machines in the ringing control circuit?
9. What will make the RM machine transfer to the subcycle?
10. What is the voltage output of the subcycle?

4-6. Troubleshooting Power and Ringing Equipment Circuits

You have progressed through troubleshooting so tar without any great difficulty. Therefore, we think you will accomplish the troubleshooting involved here with only a little more effort. Again, keep in mind that, while performing troubleshooting duties, a safe worker is an asset to any organization, and the equipment will fare much better under this condition.

637. Given power and ringing equipment symptoms, use schematic diagrams to determine the probable cause and corrective action for each.

We have studied the schematics and how the circuit operates; and the troubleshooting approach is the same. Let us see if you can now find out what causes certain functions not to happen when they should. Use the schematics, the troubleshooting approach, and the information provided to complete the exercises.

Exercises (637):

1. One of the equipment circuit breakers, shown in foldout 6, has tripped. The alarm lamp on the discharge and distribution circuit is not indicating. However, the common supervisory circuit has a fuse lamp and an emergency alarm signal. What could cause this trouble, and what is your fix?

2. The maintenance person is unable to apply calibrated voltage on the – CAL lead, shown in foldout 6, to the common supervisory circuit. What are the possible causes for this malfunction, and how would you clear them?

3. The G1 relay, shown in foldout 7, is not operated, G2 and TR are operated, what is the probable cause of this condition? What is your fix?

4. The G2 relay in the ringing control circuit chatters, what could be the problem and your correction?

5. The subcycle has no output. Delay G1 is relased. The RM machine is running but there is no ringing current in the switching equipment. What is the probable cause and the fix?

6. The ac interrupter, shown in foldout 8, is running normal and the maintenance person operates the INT ST key on the dc machine. How will this effect the ac interrupter?

7. The ac interrupter has stopped and the transfer has occurred. However, there is no output on generator leads 3, 4, 5 and 6, and TP1, TP2. What could cause this malfunction and how would you clear it?

8. Assume that the cams were stopped physically and the normal transfer took place. After repairing the ac interrupter it would not transfer back. Why?

CHAPTER 5

Attendant's Cabinet and Miscellaneous Trunk and Switching Equipment

IN CHAPTER FIVE of Volume 3 you studied about the Strowger fire and pulse repeaters, as well as the reverting call switch and the attendant's cabinet and some of its associated circuits. You are also aware by now that the XY system is similar in many ways to the Strowger.

In this chapter we look at the circuits that serve similar purposes in the XY system.

5-1. Equipment Description

In this section we discuss the purpose and functions of the fire repeater, dial-to-dial trunk circuit, inspector's ringback circuit, the attendant's cabinet circuits and some of its associated circuits.

638. State the purposes and identify the functions of the miscellaneous trunk and switching equipment and the attendant's cabinet and associated circuits. Consult foldout 9 as necessary.

XY Fire Repeaters. XY fire repeaters, shown in foldout 9, perform the same functions as those in step-by-step systems. They are mounted on the miscellaneous equipment shelf and also signal the switchboard who may or may not assist in the call according to base requirements.

The purpose of the XY fire repeater is to provide subscribers a means of calling the fire department. The telephone number for dialing the fire department is the same, 117, as it is in the Strowger system.

Two-Way Dial-to-Dial Trunk Circuit. The purpose of this circuit is to provide the subscribers with a means of dialing directly to another central office.

It can be accessed from a first selector by dialing the proper digit or from the attendant's cabinet for outgoing calls or from the banks of first selectors or the attendant's cabinet at the distant office.

It provides switchboard supervision (busy lamp), repeats the dial pulses by either loop or battery and ground pulsing, and accesses an incoming selector on incoming calls.

Inspector's Ringback Circuit. This circuit is used primarily by installer repairmen for automatically testing the bells of a telephone instrument.

This circuit is accessed from the banks of the XY special second selectors. It provides ringing on both sides of the line, alternately and works in the same way, from the user's end, as does its Strowger counterpart. It is normally mounted in the relay rack, and many offices have two of these circuits.

Attendant's Cabinet. The attendant's switchboard and associated circuit components provide service to telephone users that supplement those of the dial switching equipment in any size XY dial central office.

The attendant's cabinet (switchboard) consists of one or more positional units. The number of switchboard positions used in a central office is determined by the amount and type of service required. Usually a 200-line office includes only one position; a 1200-line office has a four-position attendant's cabinet.

The basic switchboard normally has 15 cord circuits and one position circuit. Talk monitor keys, board supervisory lamps, and a dial are parts of the key shelf equipment. The circuit apparatus for the cord circuit and for the operator's position circuit is mounted on a hinged steel gate at the rear of each switchboard. Use the switchboard as follows:

a. Complete calls between dialed telephones and nondialed telephones.

b. Complete calls to and from other exchanges (manual and dial).

c. Serve as an information center when an information desk is not provided or not in use.

d. Provide special service, such as supplying intercept facilities for the XY dial switching equipment.

e. Complete and hold fire calls.

Face equipment. Each position consists of two or three panels which extend from the top of the unit to the cord and key shelf. The panels contain the line and trunk multiple, the piling rail equipment, and jack blanks. The line and trunk multiple consists of jack, lamp, and designation strips. Blank spacers are included to separate the various groups of multiple equipment and to fill in portions of the panels where the multiple is not provided. The piling rail equipment consists of the line and supervisory pilot lamp, fuse alarm lamp, and cord test jack.

Cord and key shelf. The cord and key shelf consist of a fixed section and a hinged section. The fixed section contains the cords and plugs. The hinged section contains the cord supervisory lamps, lever switches, pushbutton switches, and a dial. The headset jacks are located on the shelf apron.

Cable turning section. The cable turning section is a matching cabinet used to cover the cables entering the switchboard position. Only one cable turning section is required for each central office, regardless of its size.

Associated equipment. The equipment associated with the attendant's cabinet is mounted on the relay rack and shelf equipment. This equipment consists of the convertible line circuit, the operator's or information trunk and the out-dial-to-connector circuits, as well as a few others not mentioned here because we do not need to discuss them further.

Exercises (638):

1. Give the purpose of the XY fire repeater.

2. Give the purpose of the XY dial-to-dial trunk circuit.

3. State the purpose of the XY inspector's ringback circuit.

4. State the purpose of the XY attendant's switchboard and associated circuits.

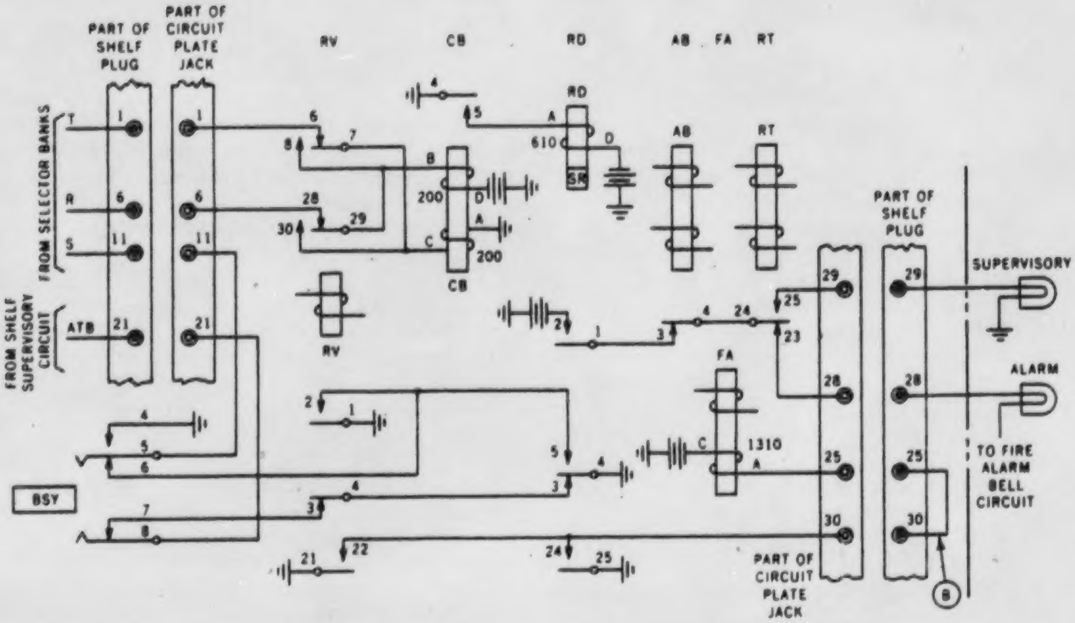
5. Specify how the XY inspector's ringback circuit is accessed in the equipment.

6. Name the two methods of repeating subscriber's dial pulses used by the XY two-way dial-to-dial trunk circuit?

5-2. Operation of Circuits

While the purpose and functions of the circuits just described is almost identical to that of Strowger equipment discussed in Volume 4; the circuit operations and schematic diagrams are quite different.

During your study of this section use the schematic diagrams, which are provided as foldouts (in a separate inclosure) with this volume, as well as the applicable figures.



PART OF SHELF PLUG
PART OF CIRCUIT PLATE JACK
RV
CB
RD
AB
FA
RT
FROM SELECTOR BANKS
FROM SHELF SUPERVISORY CIRCUIT
T
R
S
ATB
BSY
610
200
SR
1310
PART OF SHELF PLUG
SUPERVISORY
ALARM
TO FIRE ALARM BELL CIRCUIT
PART OF CIRCUIT PLATE JACK
B

Figure 5-1. Dialing the fire department.

639. Using foldout 9's schematic diagram and figures 5-1 and 5-2 as required, identify the actions that occur in the XY fire repeater during its operation and what effect each of those actions has on associated equipment.

This section describes a call that is connected to the fire department without the help of the switchboard.

Dialing a Fire Call. The calling party dials the fire reporting number. This action causes the selector to switch the users loop across relay CB, as shown in foldout 9 (the calling bridge). This causes the CB to operate, as figure 5-1 shows, and close its 4-5 contacts. This, in turn, causes relay RD (the release relay) to operate. Contacts 3-4 of RD break and remove the ground from the ATB lead to the shelf supervisory circuit. Relay RD also lights the alarm lamp (red) at the switchboard, closes the operating path to relay FA, and places ground on the S lead to mark the circuit busy and hold the preceding equipment. Relay FA, seen in figure 5-2, extends ringing to the fire department, closes the ringback tone circuit, and partially closes the operating circuit of relay RT (the ring trip). When the red alarm lamp lights at the switchboard, the operator pushes the talk key. This operates relay OC (operator cut-in) and permits the operator to monitor the call.

Fire Department Answers. When the fire department answers, relay RT partially operates. Contacts 1-2 complete the path for the fully operating RT. When RT operates fully, its contacts cut off ringing at the fire department and the ringback tone to the caller, turn off the alarm lamp at the switchboard and light the supervisory lamp, and close the operating path for relay AB. (Relay SR will not operate at this time because current in its windings is flowing in the opposite direction. If a call must be traced, the fire department attendant would push the call tracing switch, which would place a ground on the R side of the line and cause SR to operate.)

Release. When the calling party disconnects, relay CB releases and causes relay RD to release. The contacts of RD remove ground from the S lead, which releases the switch train. RD also releases FA, which in turn causes RT to release. The release of RD and RT opens the circuit to the supervisory lamp. This signals the operator, so that she may disconnect. When she does, relay OC releases, and the circuit is back to normal.

Exercises (639):

Use foldout 9 where necessary for each exercise.

1. State what happens when relay RD in the fire repeater operates.

2. Specify the type of call during which the RV relay, found in the XY fire repeater, operates.

3. Cite what holds the RV relay in XY fire repeater operated once it operates initially.

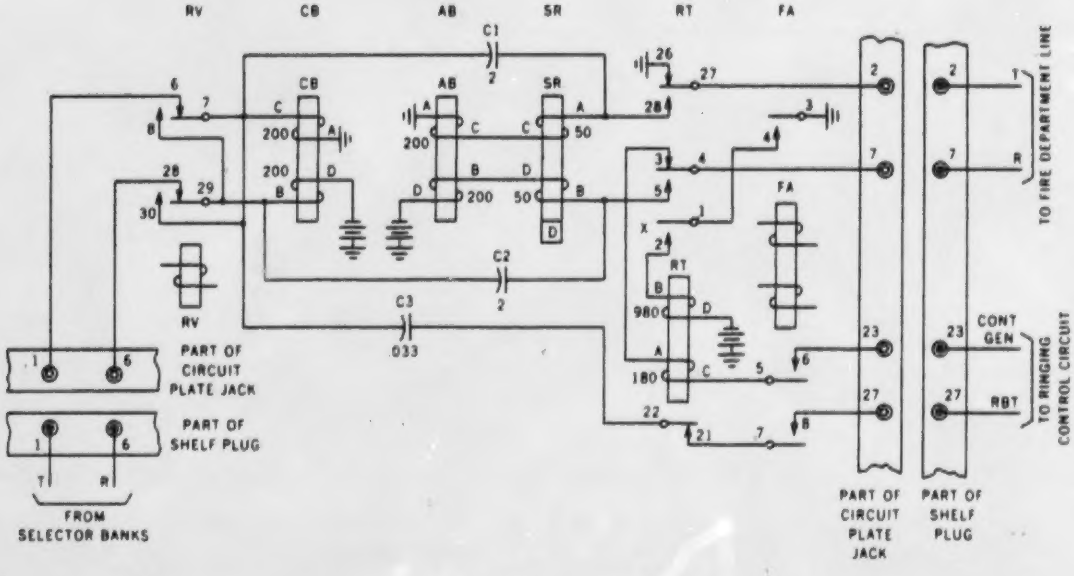


Figure 5-2. Ringing the fire department.

4. State when the C wiring option, within the XY fire repeater, is used.

5. Specify the circumstances under which the SR relay, also in the XY fire repeater, operates, and how.

6. Cite what, in the XY fire repeater circuit, causes the OC relay to operate.

640. Using foldout 10's schematic diagram as necessary, identify the actions that occur in the XY two-way dial-to-dial trunk circuit during operation and what effect each of the actions has on associated circuits.

Foldout 10 (found in a separate inclosure) shows two trunk circuits connected in the normal manner. Let the circuit at the top of the page represent the local office repeater, and let the circuit at the bottom of the page be the one in the distant office.

Seizure, Outgoing Call From the Local First Selector. As foldout 10 reveals, seizure of the trunk circuit from the local selector level causes the CB relay to operate over the subscriber's extended loop.

Relay CB (local office) operates. Contacts 3 and 4 partially prepare a loop to seize the distant office. Contacts 6 and 7 close the circuit to relay RD1. Contacts 1 and 2 prepare a circuit to place battery on the tip lead to the distant office.

Relay RD1 (local office) operates. Contacts 1 and 2 energize the bd winding of SR1. Contacts 22 and 23 and 25 and 26 close the T and R loops to the distant office, causing PL relay at the distant office to operate. The operate path for the PL relay is through the ac winding of SR1, differentially energizing the relay. Contacts 6 and 7 close the circuits to RD11.

Relay RD11 (local office) operates. Contacts 21 and 22 place a ground on the back sleeve. Contacts 3 and 4 place battery on the BL lead to light the busy lamp in the attendant's cabinet. Contacts 8 and 9 partially prepare a circuit to the peg count lead. Contacts 1 and 2 partially prepare a path to SH1. Contacts 28 and 30 partially prepare a path to RS. Contacts 5 and 6 open the idle line termination (the 510 ohm resistor and "C" capacitor). Contacts 23 and 24 prepare a circuit to place ground on the R to the distant office. Contacts 25 and 26 break and place the tip and ring loop under the control of the CB relay.

The trunk circuit (top) in the local office has been seized at this time. Meanwhile, back in the distant exchange (bottom), the PL relay has operated.

Relay PL (distant office) operates. Contacts 1 and 2 partially close the circuit to the CB relay in the incoming selector. Contacts 4 and 5 close the circuit to relay SW.

Relay SW (distant office) operates. Contacts 11 and 12 apply ground to the MSR lead to light the monitor lamp bright. Contacts 5 and 6 apply a ground on the sleeve lead forward to mark this circuit as busy to all other calls. Contacts 27 and 28 further open the ground to the ATB lead. Contacts 33 and 34 transfer control of the idle line termination to the SR2 relay.

Contacts 25 and 26 prepare the circuit to SH2. Contacts 23 and 24 close the holding circuit to itself. Contacts 21 and 22, 1 and 2, 15 and 16, 30 and 31, close the loop to the CB relay in the incoming selector. These contacts are in series with the ac winding of SR2, resistor R3, coils E and F and G and H. Contacts 3 and 4 close the circuit to the db winding of SR2, differentially energizing it. Contacts 9 and 10 place battery on the BL lead to light the busy lamp on the switchboard.

The two trunk circuits and the incoming selector are prepared to accept the dial pulses from the local office at this time. When the calling subscriber dials the CB in the local trunk, circuit will follow the dial pulses. The CB relay will cause the PL relay in the distant office to pulse. PL relay will cause the pulsing relay in the incoming selector to drive the switch in the X direction.

Impulse Break. The first break of the dial pulse springs causes the CB relay in the local trunk circuit to release.

CB relay (local office) releases. Contacts 3 and 4 and contacts 1 and 2 open the circuit to PL in the distant exchange and it releases. Contacts 6 and 7 open the circuit to RD1, placing it on slow release time. Contacts 6 and 5 close the circuit to SH1.

SH1 relay (local office) operates. Contacts 4 and 6 and contacts 21 and 23 prepare a low resistance loop to the PL relay. Contacts 1 and 2 and 3 short circuit the C2 capacitor, discharging it to prevent noise. Contacts 4 and 5 and contacts 21 and 22 remove the repeat coils from the pulsing circuit. This prevents any pulse distortion. During the time the pulse springs are closed, the CB in the local trunk circuit will operate.

PL relay (distant office) releases. Contacts 4 and 3 close the circuit to SH2. Contacts 1 and 2 open the T and R to the pulsing relay in the incoming selector.

SH2 relay (distant office) operates. Contacts 3 and 4 shunt the winding E and F of the repeat coil. Contacts 1 and 2 prepare a low-resistance path to the pulsing relay in the incoming selector.

Impulse Make. When the dial's pulse spring contacts make, the loop is again placed across the tip and ring of the local trunk circuit. This operates the CB relay in the local office trunk circuit.

CB relay (local office) operators. Contacts 1 and 2 and contacts 3 and 4 close the low resistance loop to the PL relay at the distant exchange, which operates.

Contacts 5 and 6 open the circuit to the SH1 relay, placing it on slow release time. Contacts 6 and 7 close the circuit to RD1, which was on slow release time and did not have time to release. The PL relay in the distant exchange will follow CB in the local exchange.

PL relay (distant office) operates. Contacts 3 and 4 open the circuit to SH2. However, SH2 is a slow release relay and will stay operated during pulsing. Contacts 1 and 2 close the circuit to the pulsing relay in the incoming selector.

The same series of events occurs for the next and subsequent sets of impulse break and make. After the last impulse make, dial pause occurs.

Dial Pause. During this period of time relay SH1 in the local trunk circuit releases.

SH1 relay (local office) releases. Contacts 21 and 23 open the resistance battery on the T lead. Contacts 4 and 6 open the resistance ground on the R lead. Contacts 21 and 22 and contacts 4 and 4 place the windings of the repeat coil in series with the ac winding of SR1 and the windings of the PL relay at the distant office.

SH2 relay (distant office) releases. Contacts 3 and 4 remove the shunt from the repeat coil. Contacts 1 and 2 return the T and R loop through the winding of SR2 and the repeat coil, establishing a transmission circuit through the two trunks to the incoming selector, which was stepped in the X direction by the dial. The selector will automatically search this level for an idle trunk to a connector. The next two digits will drive the connector to the desired line circuit. The connector will automatically ring the called subset.

Called Party Answers. When the called subscriber answers, the AB relay in the distant office connector operates and reverses the battery and ground to the trunk circuit at the distant exchange. The reverse battery on T and R leads applied through the connector, incoming selector, into the trunk circuit, causes relay SR2, in the distant office, to operate. The reversed battery aids the db winding of SR2.

SR2 relay (distant office) operates. Contacts 1, 2, and 3 and contacts 21, 22, and 23 reverse the battery to the local trunk, causing the SR1 relay to operate.

SR1 relay (local office) operates. Contacts 5 and 6 place battery on the HS lead. Contacts 3 and 4 further open the circuit to SH1. Contacts 25 and 26 open the idle line termination. Contacts 23 and 24 open the ATB lead. Contacts 1 and 2 close the circuit to SR11.

SR11 relay (local office) operates. Contacts 1, 2, and 3 and contacts 4, 5, and 6 reverse the battery to the calling subscriber for answer supervision. Contacts 24 and 25 place the R2 resistor in series with the monitor lamp. Contacts 21 and 22 close the circuit to the RS relay.

RS relay (local office) operates. Contacts 1 and 2 and contacts 21 and 22 open the circuit to PL. Contacts 25 and 26 place an alternate ground on SR1. Contacts 5 and 6 apply negative battery to the BL lead. Contacts 3 and 4 close a holding path to itself under control RD11.

Everything in the local and distant offices is now ready for conversation to take place. After the caller and the callee have finished talking, it is time for releasing the equipment; this is almost the same thing as "what goes up must come down."

Before we get into the circuits' actions of releasing equipment, you need to realize which relays are operated in both trunk circuits. In the local trunk relays CB, RD1, RD11, SR1, SR11, and RS are operated.

In the distant trunk relays PL, SW, and SR2 are operated.

Calling Party (Local Office) Hangs Up First. When the calling party hangs up, he opens the line loop that was the operating path of the CB relay.

CB relay (local office) releases. Contacts 1 and 2 accomplish nothing at this time. Contacts 3 and 4 open the circuit to PL at the distant exchange. Contacts 6 and 7 open the circuit to RD1, placing it on slow release.

RD1 relay (local office) releases. Contacts 1 and 2 remove one ground from SR1. Contacts 22 and 23 and contacts 25 and 26 open the circuit to the ac winding of SR1. Contacts 22 and 21 and contacts 25 and 24 partially close the circuit to PL. Contacts 7 and 6 open the circuit to RD11. Contacts 6 and 5 close the circuit to the peg count meter. Contacts 3 and 4 open the monitor lamp circuit.

RD11 relay (local office) releases. Contacts 25 and 26 partially close the circuit to PL for an incoming call. Contacts 23 and 24 further open the resistance ground to the ring side. Contacts 3 and 4 open one ground to the busy lamp at the attendant's cabinet. Contacts 21 and 22 remove one ground from the back sleeve. Contacts 30 and 28 open the lock path to RS, while 28 and 29 close a new circuit to the tip from the distant office. Contacts 5 and 6 re-establish the idle line termination. Contacts 8 and 9 open the circuit to the PC meter. The local office will remain in this condition until the distant end releases. Relays operated are SR1, SR11, and RS.

PL relay (distant office) releases. PL released because of CB relay in the local office. Contacts 1 and 2 open the loop to the connector CB relay which starts the release of the incoming selector. Contacts 4 and 5 open the circuit to SW (SW will not release until the forward switch train releases. Contacts 4 and 3 close the circuit to relay SH2 in the distant office.

Relay SH2 accomplishes nothing at this time. When the switch train releases, the ground is removed from the sleeve, and SW will release.

SW relay (distant office) releases. Contacts 3 and 4 open the circuit to SR2. Contacts 9 and 10 open the BL lead. Contacts 5 and 6 remove the busy ground from the selector wire bank. Contacts 7 and 8 and 1 and 2 further open the loop to the incoming selector. Contacts 21 and 22 further open the pulsing path to the incoming selector. Contacts 23 and 24 open the lock path to SW. Contacts 12 and 13 prepare a circuit to the monitor lamp.

SR2 relay (distant office) releases. Contacts 1, 2, and 3 open the circuit on the top side and the RS relay. Contacts 21, 22, and 23 open the circuit to R side.

RS relay (local office) releases. Contacts 25 and 26 open the circuit to SR1. Contacts 5 and 6 turn out the busy lamp. Contacts 23 and 24 remove the busy ground from the sleeve. Contacts 3 and 4 open the lock path.

SR1 relay (local office) releases. Contacts 5 and 6 open the circuit to the HS lead. Contacts 3 and 4 partially complete the circuit to SH-1. Contacts 25 and 26 close the idle line termination. Contacts 1 and 2 open the circuit to SR11.

SR11 relay (local office) releases. Contacts 1, 2, and 3 and contacts 4, 5, and 6 place the tip and ring back to normal. Contacts 21 and 22 further open the circuit to RS. Contacts 23, 24, and 25 place the monitor lamp circuit to normal.

Seizure of the trunk from the attendant's switchboard is just the same as a subscriber seizing the circuit. The operator inserts a plug into the trunk jack and dials. The circuit functions in the same manner as we described in discussing the selector access.

A call originating at the distant end will function as we have described for an outgoing call. The only difference is that the distant office originated and the local office terminates the call.

Called Party Hangs Up First. If the called party hangs up, the AB relay releases. This action reverses the battery to the calling party back to normal, causing relay SR2 in the distant office to release. At this time:

1. Relay SR2 (distant office) releases. When the SR2 relay releases, 1 and 3 and 21 and 23 reverse the battery to the local trunk back to normal, causing the SR1 relay to release.
2. Relay SR1 (local office) releases. Contacts 1 and 2 open the operating path of the RS relay, but the RS relay has a hoid path through its 3 and 4 contacts.

Exercises (640):

Use foldout 10 as necessary for each of the following exercises.

1. State what relay operates first in the XY two-way dial-to-dial trunk circuit on an incoming call.

2. Clarify what prevents early seizure of the called party's trunk circuit during the release of the call.

3. Specify when relay SR2, on an incoming call to the trunk circuit, operates and the cause of its operating.

4. State what circuit actions are a direct result of the trunk circuit's CB relay operating upon seizure.

5. Specify when relay SH1 in the local trunk on an outgoing call releases and what its releasing does.

641. Using foldout 11's schematic diagram as necessary, identify the actions in the inspector's ringback circuit during operation.

Seizure. The inspector's ringback circuit is seized when the special second selector switches through. This extends the subscriber's loop to the tip and ring of the inspector's ringback circuit, as seen in foldout 11 (found in a separate inclosure), operating the CB relay.

In our discussion of this circuit, the "W" wiring option is used. This then occurs:

CB relay operates. This action closes a circuit to RD.

RD relay operates. This action prepares a path to the SW relay. It also applies ground to the back S lead to hold the preceding equipment and to mark this circuit busy to other calls.

The Installer Hangs Up. When the inspector disconnects, the T and R loop is opened to CB. At this time:

CB relay restores. This action opens the circuit to RD; closes a circuit to SW.

RD relay remains operated. This stays operated due to its slow release characteristic.

SW relay operates. This action recloses a holding circuit to RD, applies ground to the ST lead of the common supervisory circuit, connects the REV G lead to the RV relay, connects ground to the T side of the calling line, and applies ringing generator through the ac winding of RT to the R side of the line to ring the stations on the R side of the line. When ground pulse appears over the REV G lead, a circuit is closed to RB.

RV relay operates. This transfers ground from T side of the line to the R side of the line and transfers the continuous generator lead from the R side of the line to the T side to ring the stations connected on the tip side of the line. When the ground pulse on REV G lead is removed, the circuit to RV is opened.

RV relay restores. This reapplies continuous generator to the R side of the line and reconnects ground to the T side of the line.

The Installer Lifts the Handset. When the called party answers, a direct current circuit is closed to RT due to either tripping or superimposed battery over the generator lead. At this time:

RT relay operates to its X contacts. RT operates to its "X" preliminary make contacts, closing a circuit to its bd winding.

RT relay fully operates. RT operates fully, trips the ringing, opens the circuit to SW, removes the alternate ground from the sleeve lead of the preceding equipment when "W" wiring is used. The preceding equipment will now be held by ground on the S lead via "W" wiring.

SW relay releases. SW restores, reconnects the CB relay to the T and R loop closing the circuit to CB, opens the circuit to RD, removes ground from the ST lead, and removes the REV G lead from the RV relay. RD remains operated due to its slow release characteristics.

CB relay reoperates. This recloses a circuit to RD. Circuit is now held by "W" wiring.

The Installer Hangs Up for the Second Time. When the called party disconnects, the T and R loop is opened to CB. This happens now:

CB relay restores. This action opens the circuit to RD.

RD relay restores. This action opens the circuit to RT and removes ground from the back S lead, allowing the preceding equipment to restore.

RT restores. This lets the circuit be restored to normal and makes it available for other calls.

NOTE: If "W" wiring is not used, when the call is answered, the operation of RT removes ground from the B lead of the preceding equipment, releasing the equipment, and the circuit will restore to normal upon the release of SW and RD.

Exercises (641):

Use foldout 11 as necessary for each of these exercises.

1. Specify what relays operate during seizure of the inspector's ringback trunk.

2. Clarify the initial function of contacts 3 and 4 of relay RD in the inspector's ringback circuit.

3. Specify, when the installer hangs up the first time, what actions occur in the inspector's ringback trunk.

4. Clarify—without the "W" wiring option in use—what happens in the inspector's ringback trunk when the installer lifts the handset to stop it from ringing. Why does this occur?

642. Using foldouts 12 and 13's schematic diagrams as necessary, identify the actions that occur in the attendant's cabinet and the operator's trunk circuit during operation.

The switchboard in XY central offices is made up of a position and dial circuit, and operator's circuit, and 15 cord circuits. Foldout 12 (found in a separate inclosure) is a schematic diagram of these three major circuits and how they connect together. Anything shown connected to a cord circuit is a multiple connection to all 15 cord circuits.

In addition to the above circuits, we are going to discuss the convertible line circuit, used as a magneto and a common battery circuit, and the operator's/information selector level trunk. Now let's see how each circuit, shown in foldout 12, works, as well as how well they work all together.

Operator's Circuit. The operator's circuit permits the operator to talk or monitor on any one of the cord circuits. The operator inserts the headset into jacks A and B. This completes a circuit to relay OB in series with the retardation coil RE1 and the operator's transmitter.

Transmitter circuit, primary side. The operator's headset transmitter is connected across the 7-8 winding of induction coil IC through the T leads of jacks A and B and capacitor C5. The voice currents cause capacitor C5 to charge and discharge through the 8-7 windings of induction coil IC. This change of current causes induced voltage in the 1-2 windings of induction coil IC. Voice currents are kept out of the battery by the high impedance of the windings on relay OB and coil RE1.

Transmitter circuit, secondary side. The T and R leads of the position and dial circuit are connected to the 1-2 winding of induction coil IC through capacitors C1 and C2.

Receiver circuit. This circuit is from the T lead of the position and dial circuit, terminal 2 of the operator's and position switching circuit plate terminal board, contacts 24 and 25 of relay SW1, to capacitor C1. From capacitor C1 the circuit proceeds through contacts 3 and 4 of relay MO, the 1-3 windings of induction coil IC, contacts 9-8 of relay MO, terminal 11 of the operator's and the position switching circuit plate terminal board. Then the circuit follows the RT lead, the S lead of jack A, the S lead of plug A, the receiver, the S lead of plug B, the S lead of jack B, and contacts 2-1 of jack D, the RR lead. Next, it moves through terminal 16 of the operator's board, contacts 26 and 27 of relay MO, and position switching circuit plate terminal. After this, it follows the 4-2 winding of induction coil IC and contacts 21 and 22 of relay MO to capacitor C-2. Thence the circuit goes from capacitor C-2 through contacts 22 and 21 of relay SW1, terminal 7 of the operator's and the position switching circuit plate terminal board, to the R lead of the position and dial circuit. This circuit connects the operator's receiver circuit across the T and R leads of the cord circuit.

Varistor CR1 is connected across the RT and RR leads to reduce clicks in the operator's receiver when any sudden surges of current occur in the receiver circuit, such as occur when the headset plug is inserted into the jacks.

Talking. Operating the TALK-MON switch of any cord circuit to the TALK position, completes a circuit to relay OC.

At this time we will only deal with "X" contacts 21 and 22 of relay OC. Contacts 21 and 22 complete a circuit to relay OT in the operators and position switching circuit.

Contacts 22 and 21 disconnect resistor R1 from across the T and R leads. The transmission circuit for the operator is now complete.

Voice currents through the 7-8 winding of induction coil IC induce voltage in the 1-3, 3-4, and 4-2 windings of induction coil IC. The voltage induced in these windings is extended to the T and R leads of the cord circuit.

Listening. The voice currents from the cord circuit are extended through the operator's and position switching circuit to the 1-2 winding of induction coil IC, through the circuit described under the heading Receiver Circuit. The voice currents through induction coil IC divide, with the smaller portion flowing through the 3-4 winding and the larger portion flowing through the receiver. The receiver is bridged across the 3-4 winding. Capacitors C1 and C2 open the circuit to direct current from the cord circuit to prevent the cord circuit relays from locking in the operated position and poling the receiver unit.

Now that we have the capability to talk and listen, let us get connected to a circuit and talk to someone.

Operator's Trunk Circuit. One of the most used associated switchboard circuits is the information or operator's trunks. One is accessed from the 0 level of first selectors, while the other is accessed from the third level of the special second selectors. But the same circuit is used for both.

Seizure. To seize the information or operator trunk circuit, shown in foldout 13, the T and R loop from the user's telephone is extended through the preceding switching equipment to relay CB in the trunk circuit. This causes relay CB to operate. At this point:

1. CB relay operates—Contacts 1 and 2 prepare a holding circuit for relay SL1. Contact 4 and 5 complete a circuit to relay RD.
2. RD relay operates—Contacts 1 and 2 extend ground to the ST lead. This causes the ringing equipment to function. Contacts 3 and 4 complete a circuit to the BL lead and the LL lead. This causes the busy lamp and the line lamp at the attendant's switchboard to light. Contacts 21 and 22 prepare a holding circuit for relay SL1. Contacts 24 and 25 extend ground back over the S lead to hold the preceding switch train. Contacts 23 and 24 remove a ground from the ATB lead. Contacts 5 and 6 complete a circuit for ringback tone to the calling party.

Operator answers. The lighted line lamp at the switchboard indicates an incoming call. To answer the call, the operator inserts an answer cord into the appropriate jack. This extends the T and R loop from the switchboard to the calling party. The S lead of the answer cord connects resistance negative battery to relay SL, causing SL to operate. The operation of the cord circuit will be covered later in this lesson. At this point:

1. SL relay operates—Contacts 7 and 8 provide an alternate holding circuit to relay RD. Contacts 1 and 2 and 3 and 4 open the circuit to relay CB and it releases, performing no function. Contacts 5 and 6 complete a circuit to relay SL1.
2. SL1 relay operates—SL1 contacts 23 and 24 further open the ATB lead. SL1 contacts 1 and 2 prepare a circuit to the peg count meter on the PC lead. SL1 contacts 21 and 22 complete a holding circuit for itself. SL1 contacts 25 and 26 open the circuit for ringback tone. SL1 contacts 3 and 4 remove the ground from the ST lead, causing the ringing equipment to stop functioning. SL1 contacts 5 and 6 open the circuit to the line lamp.

At this point the transmission circuit is completed between the operator and the calling party. Transmission battery is supplied by the cord circuit. During transmission relays SL, RD, and SL1 remain operated.

All good things must come to an end; and so it is with this conversation. We now look at circuit release under two conditions: (1) release, calling party first; and (2) the operator disconnects first.

Release, calling party first. If the calling party disconnects first, the supervisory lamp at the switchboard lights. The operator then removes the answer cord from the trunk circuit jack. This opens the circuit to relay SL. Then,

1. SL relay releases. Contacts 7 and 8 open the circuit to relay RD. The remaining contacts of relay SL are of no importance at this time.
2. RD relay releases. Contacts 3 and 4 open the circuit to the busy lamp. Contacts 24 and 25 remove the ground from the S lead, causing the preceding equipment to release. Contacts 23 and 24 complete a circuit to the peg count meter over the PC lead. Contacts 21 and 22 open the circuit to relay SL1. The remaining contacts have no importance at this time.
3. SL1 relay releases. Contacts 1 and 2 remove the ground from the PC lead. Contacts 23 and 24 place a ground on the ATB lead. The remaining contacts have no importance at this time.

Operator disconnects first. The operator removes the answer cord from the trunk jack. This opens the circuit to relay SL. Then,

1. SL relay releases—Contacts 1 and 2 and 3 and 4 complete a circuit to relay CB. Contacts 7 and 8 open the circuit to RD. RD is a slow-to-release relay. It thus

remains operated long enough for relay CB to operate to complete a holding circuit to it.

Exercises (642):

1. State what relays in the cord circuit, shown in foldout 12, operate from the sleeve of an answer cord that is plugged into an operator's trunk line jack (FO 13).

2. Give the purpose of the ground at contacts 1 and 2 of relay CB in the operator's trunk.

3. State the functions contacts 24 and 25 of relay RD in the operator's trunk perform.

4. List the three functions accomplished by the operation of relay SL in the operator's trunk.

643. Using foldouts 12 and 13's schematic diagrams, as necessary, identify the actions that occur in the attendant's cabinet, the information trunk, and the out-dial-to-connector circuits during operation.

Cord Circuit. Let us now look at the cord circuit for a short while. You remember that the attendant's cabinet in the Strowger system used the sleeve condition of the line jack to determine which circuits required that transmission battery be supplied by the cord circuit and which do not.

Similarly, the operation of the XY cord circuit relays is determined by one of three conditions on the jack sleeve: (1) low-resistance ground, (2) high-resistance ground, or (3) absence of ground. The operation of the cord circuit relays determines whether the cord circuit will supply transmission battery to the line and whether supervision will be provided. The conditions of the jack sleeve are determined by the circuit to which it is connected.

Low-resistance ground on the sleeve. The cord circuit provides ground and transmission battery to the T and R leads of the cord plug and loop supervision under this condition.

The circuits that provide low-resistance ground on the jack sleeve are CB lines, O level trunk, information trunk, dead selector level trunk, and connector intercept trunk.

High-resistance ground on the sleeve. The LB line circuit and combination trunk are arranged to provide this potential on the jack sleeve. The cord circuit does not provide transmission battery and ground; however, ring off supervision is provided.

Absence of ground (open sleeve). When ground is not present on the S lead of the jack sleeve, the cord circuit does not provide transmission battery and ground. Reverse battery supervision is provided from the out-dial-to-connector, dial-to-dial trunk, and out-dial-to-line, and the jack sleeve is open.

With a new appreciation of the wonders of the cord circuit, we move to an incoming call on the operator's trunk and how it works in conjunction with the cord circuit. Foldouts 12 and 13, found in a separate inclosure, will be used during this discussion. The out-dial-to-connector circuit is not shown in this volume. It is connected, as was the Strowger circuit, in multiple with the tip and ring leads of the connector; with a busy lamp (BL) lead connector to a set of RD relay contacts; which place a ground on the lead, when the connector is in use, to light the busy lamp.

Call from Information Trunk to Out-Dial-to-Connector Trunk. The first description of circuit operation will be a call from a subscriber through the operator trunk (low resistance on sleeve) to another subscriber through an out-dial-to-connector trunk.

Seizure. The subscriber dials through a normal switch train and seizes the information trunk, shown in foldout 13. At this point the CB operates and completes a circuit to the RD relay.

RD relay operates. At this time contacts 3 and 4 complete a circuit to the line lamp. This signals the operator of an incoming call.

Operator answers. Operator inserts answer plug into information jack. The operator's trunk, shown in foldout 13, has a low-resistance ground on the sleeve. This ground is through the 320-ohm winding of relay SL. At this time a circuit is completed to relays RHS and RLS in the cord circuit, shown in foldout 12, and relay SL of the information trunk, shown in foldout 13.

a. Relays (cord circuit) RHS, RLS operate. RHS performs no important function at this time. RLS contacts 8 and 9 complete a circuit to the answer cord supervisory lamp. RLS contacts 2 and 3 and 5 and 6 extend ground and battery to the calling party and close a circuit to relay RB.

b. SL relay (info circuit) operates. SL relay in the operator's trunk opens the circuit to CB and completes a circuit to SL1. SL1 opens the circuit to the line lamp.

c. RB relay (cord circuit) operates. Contacts 1 and 2 open the circuit to the answer cord supervisory lamp.

Operator operates TALK-MON key to the TALK position. With the key in the TALK position, its contacts 1D and 2D complete a circuit to operate the OC relay to its "X" contacts. At this point:

a. OC relay operates to its "X" contacts. Contacts 1 and 2 complete the circuit to operate the OC relay fully.

b. OC operates fully and MR relay operates. The OC and MR relays are in series through OC "X" contacts. Both relays operate at this time.

OC contacts 10 and 12 and 13 and 14 make before contacts 11 and 10 and 14 and 12 break. These contacts insert part of the position and dial circuit between the T lead of the answer cord plug and terminal 5 of the repeating coil RC; without opening the circuit. Contacts 25 and 27 and 28 and 29 make before contacts 26 and 25 and 29 and 27 break. These contacts insert part of the position and dial circuit between the R lead of the answer cord plug and terminal 8 of repeating coil RC without opening the circuit. Contacts 5 and 7 and 8 and 9 make before contacts 6 and 5 and 9 and 7 break. These contacts insert part of the position dial circuit between the T lead of the call cord plug and terminal 1 of repeating coil RC without opening the circuit. Contacts 30 and 32 and 33 and 34 make before contacts 31 and 30 and 34 and 32 break. These contacts insert part of the position and dial circuit between the R lead of the call cord plug and terminal 4 of repeating coil RC without opening the circuit. Contacts 21 and 22 complete a circuit to relay OT in the operator's circuit.

MR contacts 1 and 2 complete the circuit to relay MR1. MR contacts 3 and 4 open the operating circuit to the OC relays in the other cord circuits. This prevents the OC relays of two cord circuits from operating at the same time if two TALK-MON switches are operated to the TALK position. MR contacts 6 and 7 prepare a circuit to relay TR in the operator's circuit.

c. OT and MR1 relays operate. OT contacts 22 and 21 disconnect resistor R1 from across the T and R leads. MR1 contacts 1-2 remove ground from the CT lead to the succeeding position. This prevents a double connection during position switching.

Conversation and connector seizure. At this point conversation can now take place between the operator and the calling party. Transmission battery to the calling party is furnished by the cord circuit. Battery is supplied through the db winding of relay RB. Ground is supplied through the bd winding of relay RLS. The operator will now extend the call for the calling party using an out-dial-to-connector trunk. (See FO 3 for the tip and ring connections to the connector circuit.) The out-dial-to-connector trunk has no potential on the sleeve. The operator inserts the call cord into an out-dial-to-connector jack. This completes a circuit to relay FB and the CB in the connector. Battery and ground to operate the FB is furnished from the connector through the windings of relay CB. Here:

a. FB relay operates, and the connector is seized. Contacts 2 and 3 complete a circuit to light the call cord supervisory lamp. The circuit is now completed to the connector for the operator to dial the desired numbers. Operator turns dial off normal. When the dial is turned off normal, the shunt springs close and completes a circuit to relay FON.

b. Relay FON operates. Contacts 6 and 5 open the circuit to relay OT in the operator's circuit. Contacts 24 and 23 and 26 and 25 open the T and R leads to the operator's circuit. Contacts 21 and 22 and 3 and 4 connect capacitor C2 across the RT1 and RR1 leads. This prevents clicks in the receiver of the calling party when FON1 operates or releases. Contacts 1 and 2 complete a circuit to relay FON1.

c. Relay OT releases and FON1 operates. OT contacts 21 and 22 connect resistor R1 across the T and R leads in the operator's circuit. FON1 contacts 1-2 and 21-22 make first and connect the impulse springs of the dial to the FT and FR leads in series with resistor R2 to hold the connector operated. FON1 contacts 3-4 complete the hold circuit to relay FON. FON1 contacts 23-24 shunt resistor R2 from the dialing circuit. FON1 contacts 26 and 25 and 6 and 5 disconnect the FT and FR leads from the FT1 and FR1 leads. This opens the circuit to the 1 and 3 and 4 and 2 windings of repeat coil RC in the cord circuit and FB relay.

d. FB relay releases. Contacts 2-3 extinguish the call cord supervisory lamp. At this point, the impulse springs of the dial are connected across the CB relay in the connector through the call cord.

Dial pulses. While the dial returns to normal, the impulse springs break and make. This opens and closes the circuit to CB relay in the connector, stepping the XY switch in the X direction.

Dial returns to normal. The impulse springs are closed now maintaining the connector operated. The shunt springs break and open the circuit to relay FON1. Therefore:

a. Relay FON1 releases. Contacts 23 and 24 remove the shunt from resistors R2. This places resistor R2 in series with the impulse springs and the FT and FR levels. Contacts 6 and 5 and 26 and 25 connect the FR and FT leads to the FR1 and FT1 leads from the cord circuit to complete a loop circuit to relay FB. This causes FB to operate. Contacts 3 and 4 open the circuit to relay FON. Contacts 1 and 2 and 21 and 22 open the circuit from the impulse springs of the dial to the cord circuit.

b. Relay FB operates and relay FON releases. FB contacts 2 and 3 complete a circuit to light the call cord supervisory lamp. FON contacts 3 and 4 and 21 and 22 open the circuit from capacitor C2 to the cord circuit. FON contacts 6-5 complete a circuit to relay OT of the operator's circuit. FON contacts 26 and 25 and 24 and 23 connect the T and R leads of the operator's circuit to the RT1 and RR1 leads.

c. Relay OT operates. Contacts 21 and 22 remove resistor R1 from across the T and R leads in the operator's circuit. The circuit will function just as we have already described for the digit dialed to step the XY switch in the Y position. After dialing has been completed, the connector rings the called party.

The called party answers. When the called party answers his line loop is closed. At this point:

a. Relay AB operates in connector. When the called party answers, the AB relay in the connector operates. Relay AB reverses the battery and ground potential on the T and R leads to the call cord. This permits the current to flow through the B section of rectifier RF1 and shunts relay FB.

b. FB relay releases. Contacts 2 and 3 extinguish the call cord supervisory lamp. This is a visual indication to the operator that conversation is taking place. The operator will now restore the TALK-MON switch.

c. TALK-MON switch is restored. Contacts 1D-2D open the circuit to the dc winding of relay OC. Contacts 1C-2C open the series circuit to the ac winding of relay OC and relay MR.

d. Relay OC and MR release. OC contacts 4 and 3 prepare the ring-off recall circuit to the call cord. OC contacts 24 and 23 prepare the ring off recall circuit to the answer cord. OC contacts 21 and 22 open the circuit to relay OT.

The remaining contacts of OC disconnects the position and dial circuit from the cord circuit and connect the T and R leads of the cords to repeating coil RC without opening the loop circuit.

MR contacts 3 and 4 partially close the operating circuits for the OC relays in the other cord circuits. MR contacts 1 and 2 open the circuit to relay MR1. The remaining contacts have no function at this time.

OT and MR1 relays release—OT contacts 21 and 22 place resistor R1 across the T and R leads of the operator's position circuit. MR1 contacts 1 and 2 place ground on the CT lead. The operator is now disconnected from the cord circuit and the position and dial circuit. Conversation can now take place between the calling and called party. The position and dial circuit is freed from the cord circuit ready to be used by the operator for another call.

Monitoring. If the operator wishes to monitor the conversation, the operator will operate the TALK-MON switch to the MON position. Its 1B and 2B contacts complete a circuit to relay MO. Thus:

Relay MO operates. Contacts 4 and 3 and 22 and 21 disconnect the T and R leads from induction coil IC to open the transmitter circuit. Contacts 8 and 10 and 26 and 28 make and connect the operator's receiver to repeating coil RC before contacts 9 and 8 and 27 and 26 break and disconnect the receiver from the induction coil IC. The monitoring circuit is now complete. At this time the operator can restore the TALK-MON switch to normal.

TALK-MON switch to the normal position. Contacts 1B and 2B open the circuit to relay MO. At this point:

a. MO relay releases. Contacts 4 and 3 and 22 and 21 connect the T and R leads to induction coil IC. Contacts 9 and 8 and 27 and 26 make and connect the receiver circuit to induction coil IC before contacts 8 and 10 and 26 and 28 break and open the circuit to repeating coil RC. These contacts prevent clicks on the T and R loop through the cord circuit. The operator's circuit is now back to normal. When the calling party disconnects, the T and R loop to the RB relay in the cord circuit is opened.

b. RB relay releases. Contacts 1 and 2 complete a circuit to light the answer cord supervisory lamp. The next function will be the called party releasing. When the called party disconnects, the answer bridge relay AB in the connector releases and changes the polarity of the T and R leads to the out-dial-to-connector jacks. This causes FB relay to operate.

c. FB relay operates. Contacts 2-3 complete a circuit to the call cord supervisory lamp. The FB relay will remain operated until the operator removes the call cord.

Operator removes the answer cord. When the answer cord is removed, the circuit to relays RHS and RLS in the cord circuit and relay SL in the operator's trunk release. Here:

a. RHS and RLS in the cord circuit and S1 in the operator's trunk release. RHS contacts perform no function at this time. RLS contacts 8-9 open the circuit to the answer cord supervisory lamp. The remaining contacts of RLS have no function at this time. SL contacts 7 and 8 open the circuit to RD. SL contacts 6 and 5 open the operating path to SL1 in the operator's trunk. SL1 will not release until RD releases.

b. RD relay in the operator's trunk releases. Contacts 24 and 25 remove the ground holding the preceding equipment operated. The preceding switch train now releases. Contacts 22 and 21 open the circuit to SL1 relay. The remaining contacts of RD have no function at this time.

c. SL1 relay in the operator's trunk releases. Contacts of SL1 have no function at this time. The information trunk is now at normal.

Operator removes the call cord. When the call cord is removed, the circuit to relay FB in the cord circuit and CB of the connector is opened. Here:

a. FB relay in the cord circuit releases and CB relay in the connector releases. FB contacts 2-3 open the circuit to the call cord supervisory lamp. CB contacts restore the connector to normal. The cord circuit is at normal, now ready for the operator to receive and place another call.

The next description will cover the operation of a call from a local battery telephone to a common battery telephone. An LB telephone will be connected to the convertible line circuit.

Exercises (643):

1. Specify the type of sleeve the switchboard line jack of an operator's trunk, shown in foldout 13, has.

2. Give the main function of the RLS relay in the cord circuit, shown in foldout 12, when it is operated.

3. Specify what relay(s) operate(s) in the cord circuit, shown in foldout 12, when the call cord is plugged into an out-dial-to-connector jack.

4. State what happens in the cord circuit, front cord, shown in foldout 12, when the AB relay in the connector operates, and why.

644. Using foldout 14's schematic diagrams, as necessary, identify the actions that occur in the attendant's cabinet and the convertible line circuit during operation.

Call From a LB to a CB Circuit. The convertible line circuit, shown in foldout 14, (found in a separate inclosure) can be used as a line circuit for LB (local battery) and CB (common battery) telephones. It also can be used as a trunk circuit from one central office to another. Using the convertible line circuit as a trunk circuit is not a common practice, so this function will not be covered here.

Incoming call from a LB telephone, using wiring options E, F, G, X, and Y. Used as a LB circuit, the convertible line circuit, shown in foldout 14, provides a high-resistance ground on the sleeve. Transmission battery for the calling party will be furnished by the LB telephone. The LB subscriber lifts the handset of his telephone, operates the hand generator, and ringing current operates the LR relay in the convertible line circuit to its "X" contacts. At this point:

a. LR relay in the convertible line circuit operates to "X" contacts. "X" contacts 1-2 complete the circuit to operate the LR fully.

b. LR relay operates fully. Contacts 7 and 8 open the ringing circuit. Contacts 5 and 6 complete a circuit to light the line lamp at the switchboard. This signals the operator of an incoming call. Contacts 3 and 4 light the busy lamp at the switchboard.

The operator inserts an answer cord into the line jack. When the incoming line lamp lights, the operator inserts an answer cord plug into the jack associated with the incoming line lamp. This completes a circuit to relay SL in the convertible line circuit and relay RHS and RLS in the cord circuit. The high resistance of the circuit prevents RLS from operating. Here:

a. SL relay in the convertible line circuit and RHS of the cord circuit operate. SL contacts 21 and 22 close a circuit to relay CO in the convertible line circuit. RHS contacts 1 and 2 prepare a circuit for recall operation. This operation will be described elsewhere in this circuit description.

b. TALK-MON switch is operated to the TALK position. Contacts 1D and 2D complete a circuit to operate the OC relay to its "X" contacts.

c. OC relay operates to "X" contacts. Contacts 1-2 complete the circuit to operate the OC relay fully.

d. OC relay operates and MR relay operates. The OC and MR relays are in series through relay OC's "X" contacts. Both relays operate at this time.

OC contacts 10 and 12 and 13 and 14 make before contacts 11 and 10 and 14 and 12. These contacts insert part of the position and dial circuit between the T lead of the answer cord plug and terminal 5 of repeating coil RC without opening the circuit. OC contacts 25 and 27 and 28 and 29 make before contacts 26 and 25 and 29 and 27 break. These contacts insert part of the position and dial circuit between the R lead of the answer cord plug and terminal 8 of repeating coil RC without opening the circuit.

OC contacts 5 and 7 and 8 and 9 make before contacts 6 and 5 and 9 and 7 break. These contacts insert part of the position and dial circuit between the T lead of the call cord plug and terminal 1 of repeating coil RC without opening the circuit.

OC contacts 30 and 32 and 33 and 34 make before contacts 31 and 30 and 34 and 32 break. These contacts insert part of the position and dial circuit between the R lead of the call cord plug and terminal 4 of repeating coil RC without opening the circuit. OC contacts 21 and 22 complete a circuit to relay OT in the operator's circuit. MR contacts 1 and 2 complete the circuit to relay MR1.

MR contacts 3 and 4 open the operating circuit to the OC relays in the other cord circuits. This prevents the OC relays of the cord circuits from operating at the same time if two TALK-MON switches are operated to the TALK position. MR contacts 6 and 7 prepare a circuit to relay TR in the operator's circuit.

e. OT and MR1 relays operate. OT contacts 22 and 21 disconnect resistor R1 from across the T and R leads. MR1 contacts 1 and 2 remove ground from the CT lead to the succeeding position. This prevents a double connection during position switching.

LB subscriber and the operator talk. At this point, conversation can take place between the operator and the calling party. Transmission battery for the calling party is furnished by the LB telephone. The operator will now extend the call for the calling party to a CB telephone. The CB line jack has a low-resistance ground on the sleeve, furnished by the convertible line circuit. The operator then inserts the call cord into the CB subscriber's line jack. This completes a circuit to relays FHS, FLS of the cord circuit, and relay SL of the convertible line circuit.

NOTE: Look at table 2 seen in the lower right-hand corner of foldout 14. You see that wiring options A, B, C, D, X, and Y are used to convert this to a common battery circuit. Keep this in mind for the remainder of the discussion. Here:

a. FHS and FLS relays operate and SL relay operates. SL contacts complete a circuit to relay CO of the convertible line circuit. FHS relay performs no function at this time. FLS contacts 8 and 9 complete a circuit to light the call cord supervisory lamp. FLS contacts 2 and 3 extend ground to the T lead of the call cord. FLS contacts 5 and 6 extend negative battery to the R lead of the call cord.

b. Relay CO in the convertible line circuit operates. Contacts 1-2 open the circuit to relay LR in the line circuit. Contacts 4-5 complete a circuit to light the busy lamp at the switchboard. Relay FB does not operate at this time, because the T and R leads are open at the CB telephone. The call cord supervisory lamp is lighted, and the circuit is prepared for the operator to signal the called telephone by applying ringing current to the call cord. To apply ringing current to the called line, the operator must operate the RING REAR-RING FRONT switch to the RING FRONT position.

c. RING REAR-RING FRONT switch is operated to RING FRONT position. Ringing current is applied to the ring side of the call cord to ring the called party's telephone. The circuit for ringback tone is now complete to the calling party.

d. The operator restores RING REAR-RING FRONT switch to normal. This operation removes ringing current from the line to the calling party.

Called party answers. This closes the T and R loop and causes FB relay in the cord circuit to operate. Thus:

a. FB relay operates. Contacts 1 and 2 open the circuit to the call cord supervisory lamp. Conversation can now take place between the calling and called party. The operator will now disconnect.

b. The operator restores the TALK-MON switch to normal. Contacts 1D and 2D open the circuit to the b-d winding of relay OC. Contacts 1C and 2C open the series circuit to the ac winding of relay OC and relay MR.

c. Relays OC and MR release. OC contacts 4-3 prepare the ring-off recall circuit to the call cord. OC contacts 24 and 23 prepare the ring-off recall circuit to the answer cord. OC contacts 21 and 22 open the circuit to relay OT. The remaining contacts of OC disconnect the position and dial circuit from the cord circuit and connect the T and R leads of the cords to repeating coil RC without opening the loop circuit. MR contacts 3 and 4 prepare the operating circuits for the OC relay in the other cord circuits. MR contacts 1 and 2 open the circuit to relay MR1. The remaining contacts have no function at this time.

d. OT and MR1 relays release. OT contacts 21 and 22 place resistor R1 across the T and R leads of the operator's position circuit. MR1 contacts 1 and 2 place ground on the CT lead. The operator is now disconnected from the cord circuit and the position and dial circuit. The position and dial circuit is freed from the cord circuit ready to be used by the operator for another call.

Calling party (LB) disconnects first. Disconnect by the LB telephone user does not affect the line circuit. The subscriber will then operate the hand generator in the telephone. This will cause the RB relay in the cord circuit to operate. Here:

a. RB relay operates. The first half of the ringing cycle is negative on the tip. The ringing path during one half of the ringing cycle is from the LB telephone over the T side of the line, through section B of rectifier RF2 to the R side of the line and back to the telephone. Section B of rectifier RF2 shunts the winding of relay RB of this half cycle.

The other half of the ringing cycle is negative on ring. The other half of the ringing cycle flows over the operate circuit of relay RB. This circuit is from the LB telephone over the R side of the line, through the ac winding of relay RB section A of rectifier RF2, and back to the telephone over the T side of the circuit.

Contacts 2-3 complete a circuit to the answer cord supervisory lamp. These contacts also complete a holding circuit for relay RB through its db winding. Relay RB is now held operated until the operator removes the answer cord.

b. The operator removes the answer cord. The circuit to relay RHS is opened, causing it to release. This also opens the circuit to relay SL in the line circuit.

c. RHS relay and SL relay in the line circuit release. RHS contacts 1 and 2 open the holding circuit to relay RB. SL contacts 21 and 22 open the circuit to relay CO.

d. RB relay and CO relay in line circuit release. RB contacts 2 and 3 extinguish the answer cord supervisory lamp. The circuit for the answer cord is now restored to normal. CO contacts 4 and 5 extinguish the busy lamp on the switchboard. The line circuit is now restored to normal.

Called party disconnects. The line circuit is not affected when the telephone subscriber releases. The T and R loop is now open and relay FB releases. Thus:

a. FB relay releases. Contacts 2 and 1 complete a circuit to the call cord supervisory lamp.

b. The operator removes the call cord. When the call cord is removed, the circuit to relay FHS and FLS in the cord circuit and relay SL in the line circuit release.

c. FHS and FLS relays release; relay SL in the line circuit releases. Relay FHS performs no function in releasing. FLS contacts 8 and 9 open the circuit to the call cord supervisory lamp. The remaining contacts of FLS restore the call cord circuit to normal. SL contacts 21 and 22 open the circuit to relay CO.

d. CO relay in the line circuit releases. Contacts 4 and 5 extinguish the busy lamp at the switchboard. The line circuit is now restored to normal. This completes the description of a complete call from seizure to release between LB telephone and CB telephones.

Exercises (644):

Use foldout 14 as necessary for each of the following exercises:

1. State what wiring option "G" in the convertible line circuit (FO 14) accomplishes when it is used.
2. Specify how is the convertible line circuit (FO 14) used, when the operate (full) path of the LR relay uses both relay windings.
3. Clarify, when the convertible line circuit (FO 14) is used as a CB circuit, what relay(s) operate when the subscriber goes off-hook.
4. State what circuit action is responsible for the operation of relay CO in the convertible line circuit (FO 14), when it is used as a LB circuit.

5-3. Troubleshooting

Here we are again; and once again, this is "where it's at!" Your main function is to provide—SAFELY—the very best telephone service that you can. When everything works right, your only action is to monitor and check equipment operation. Everything you have been taught or will learn, in the years to come, is for the purpose of finding and fixing troubles, so that your subscribers have high quality, uninterrupted service.

645. Given miscellaneous trunk and switching equipment and attendant's cabinet trouble symptoms and using foldouts 11, 12, 13, and 14's schematic diagrams as necessary, identify the probable causes of trouble and the proper corrective actions in each situation.

Let's review the situation; you are or should be in possession of the systematic troubleshooting approach that was discussed in Volume 2 of this course. You have used that approach throughout Volume 3 and 4 to pinpoint troubles in the Strowger and XY telephone systems.

In this chapter we have presented the circuit operations to you that must be understood in order for you to adequately troubleshoot the attendant's cabinet as well as miscellaneous trunk and switching equipment associated with it. As you have worked your way through the "action" exercises related to the cabinet and equipment just referred to, you have revealed the extent of your understanding of these operations.

Now, at this point, it seems advisable to test your ability to "put it all together" again, this time in relation to a series of problem situations through which you must troubleshoot your way. Here, then, are the situations. The exercises related to them appear just following the situations.

The situations are these:

- Something is wrong with the contacts in the operator's and the position circuit (shown in FO 12). How do you know? Easy: The operator cannot monitor, as he should be able to do.
- The AB relay in the connector operates all right. But the supervisory lamp for the call cord (shown in FO 12) stays lit *after* the AB relay in the connector operates. Where could the problem be, and what can you do about it?
- The operator's trunk circuit (shown in FO 13) is seized, yet the line lamp does not light up. Also, the calling party does not hear the ringback tone at all. Could there be a problem with one or another set of contacts? If so, which?
- What is the trouble which has popped up in the convertible line circuit (shown in FO 14)? It occurs when the CB subscriber's busy lamp extinguishes when the operator inserts a plug into the line jack of the circuit? Can you find the problem, and if so, how would you handle it?
- An installer, checking equipment out, dials the number for the ringback circuit (shown in FO 11). Then he hangs up. But when the telephone rings and he answers and hangs up a second time, the telephone doesn't stop ringing; it goes on and on. You are assured that "W" wiring has been used. So what on earth can be wrong, and how should you go about taking care of it?

Okay, so now you have five problem situations, each of them typical of the kinds you will run into again and again. Consider them carefully. Not only will you right now, below, have to resolve all five of these problems—one way or another—but also the way in which you go about resolving these situations, as well as the solutions you come up with, will likely be good indicators of how competently you handle your job.

Exercises (645):

Use foldouts 11, 12, 13, or 14 as needed for these exercises.

1. You find that the monitor really can*not* monitor. Your first guess is that something is faulty in the

operator's and the position circuit? So you check it out? What do you come up with?

2. The AB relay in the connector operates all right, you're sure. Yet the supervisory lamp for the call cord remains lit *after* the AB relay in the connector operates. If the most probable trouble lies in the cord circuit, what can it be? What corrective action should you take?

3. Normally, when the operator's trunk circuit is seized, the line lamp lights up and the calling party hears the ringback tone. But in the particular operator's trunk circuit before you, when *it* is seized, the line lamp does *not* light up. Also, the calling party does *not* hear the ringback tone. Does the problem lie with one or another set of contacts? Checking this out, you find your guess to be right: the problem *does* lie in one particular set of contacts. Which one is at fault?

4. You have been called in because the CB subscriber's busy lamp extinguishes when the operator inserts a plug into the line jack of the circuit. You know—or think you know—that the problem exists in the convertible line circuit? So okay, can you find just what the trouble is, and then resolve it?

5. Told that an installer, checking equipment, has dialed the number for the ringback circuit, then hung up, you say, "So what?" Then you're told that when the telephone rings and he answers and hangs up a second time, the telephone doesn't stop ringing. You ask and are told further that "W" wiring has been used. What, then, *is* the trouble? How would you go about properly correcting it?

CHAPTER 6

Central Office Maintenance

IN THE FIRST five chapters of this volume you have covered most of the circuits that you will encounter when working in an XY exchange. The purpose of this chapter, then, is to conclude things by looking quickly at some of the "odds and ends" of maintenance—things that occur and have to be taken care of daily in an XY exchange.

We will examine some test equipment peculiar to this system, to call tracing procedures, and to shelf designation cards and the GTA drawing.

6-1. PMIs, Test Equipment, and Troubleshooting

Our subject here will be several pieces of test

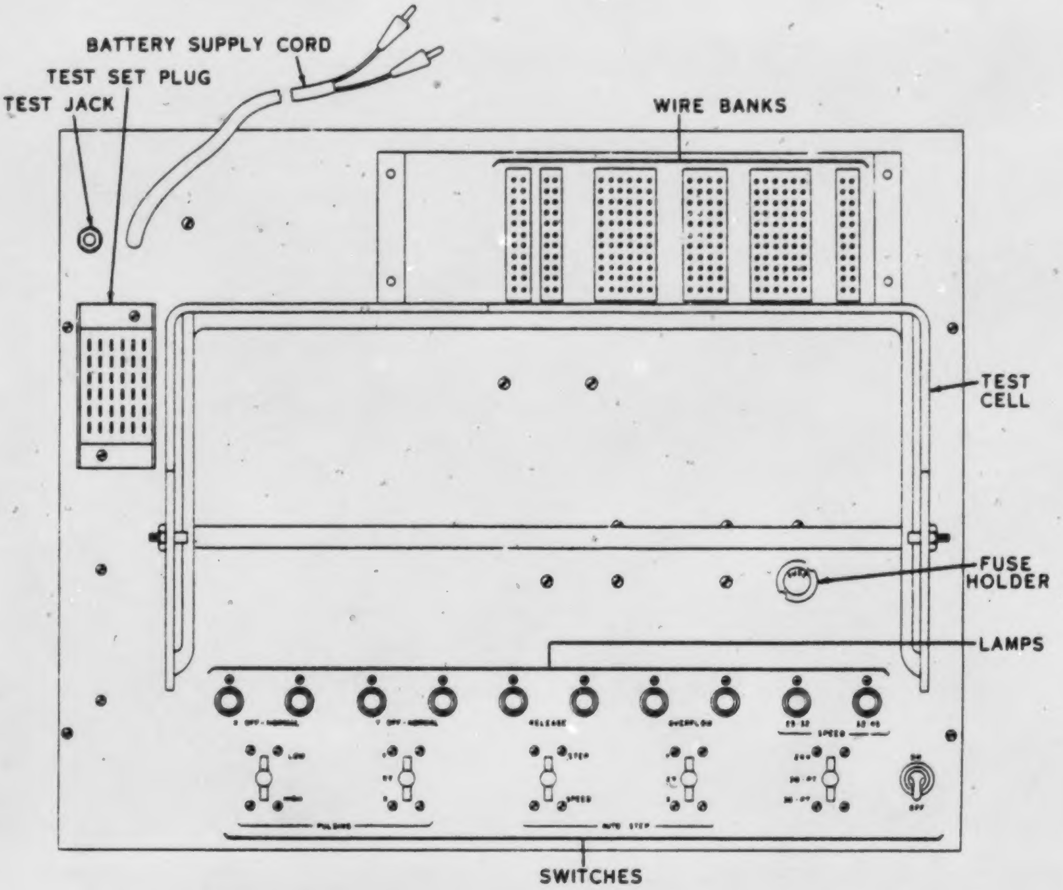


Figure 6-1. XY switch test set.

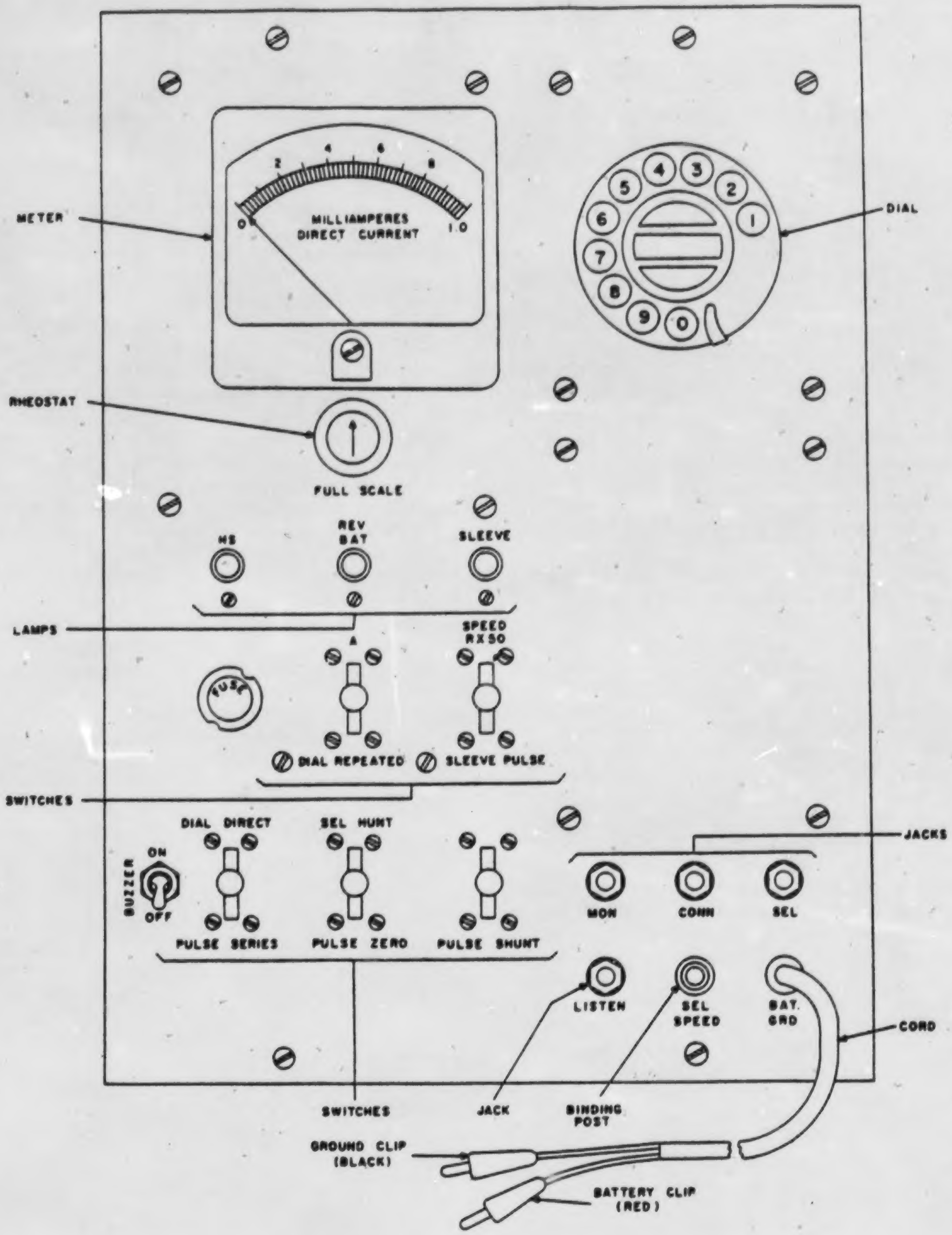


Figure 6-2. XY circuit plate maintenance test set.

equipment used to perform type 1 and type 3 PMIs in the XY exchange as well as how they can be used during troubleshooting. In case you've forgotten those types of PMIs covered in Volume 2, they apply here, too.

646. Using figures 6-1, 6-2, 6-3, and 6-4 as necessary and given typical equipment operation, identify the type of PMI and test equipment to be used to localize each problem and state the approach that should be used in each situation.

Portable Test Set for XY Universal Switch. Figure 6-1 identifies components seen on an XY switch test set. The test cell holds the XY switch while it is being tested. The 2-conductor (one red and one black) battery cord connects the test set to a battery source. The wire banks provide a means for strapping when checking an XY switch. The 36-point test plug connects the XY switch under test to the test set. The switchboard type test jack enables the repairman to measure pulse speed of the test set. Of the ten lamps pictured, four have red jewels and four have white jewels. These lamps indicate the position of contacts for off-normal release and overflow springs on the XY switch being tested. The remaining two lamps have green jewels. They indicate the stepping speed of the XY switch being tested. You can see the five 3-position lever switches and the 2-position ON-OFF switch near the edge of the test set. Each switch has been identified with a control terminology that conforms with the action it provides. For instance, the left-hand switch controls the XY switch circuits when you are testing the low-pulse ratio and the high-pulse ratio.

Although this test set is useful only to the equipment of one system, it also provides pulses for testing switch components. The wipers of the switch make contact with the wire banks of the test set when you lock the two units together. You press the XY switch jack onto the test set plug, thus making additional connections. In effect, then, you have positioned the switch as it would be in the equipment, since the test set provides the required potentials to the switch terminals. By pulling of a lever switch toward you or pressing it away from you, you complete circuits of the switch. If they respond as designed, lamps will indicate the normal actions. Otherwise the lamps will show a circuit defect. For instance, Y off-normal springs 1-and 2 normally touch. When you press the XY auto step switch, shown in figure 6-1, to the Y position, the white OFF-NOR lamp should glow. If it does not, off-normal contacts are open. The additional checking that you do will provide similar results, because of the circuits being completed by lever switches.

This test set is used for the performance of a type 2 PMI, as well as for operationally checking the XY switch during troubleshooting.

Circuit Plate Maintenance Test Set. A telephone switching center repairman uses this test set to perform operational tests on circuit plates of the XY telephone system. The condition of the equipment is revealed by lamps, meters, and buzzers. Figure 6-2 identifies test set devices and their position on the panel which supports them. Again, you can see a 2-conductor power cord. In addition to the cord, there are five lever switches, a toggle switch, three switchboard type jacks, a holder for a 2-ampere fuse, three lamps (two red and one green), a rotary control resistor (rheostat), a 0-1.0-range dc milliammeter, and a dial.

The dial is the pulsing device for this test unit. The connection of the test set to battery is provided by the battery supply cord. You must use two test cords to make the additional connections from the test unit. One test cord plug is inserted into the MON jack of the test set, while a plug of another test cord is pushed into the CONN jack of the test set. The plugs at the opposite end of the two cords are to be connected to the circuit plate of the equipment. Remember: The actual plug insertions will be determined by the test to be made. These equipment connections enable you to complete pulsing circuits with the operation of the lever switches. Again, you can see the similarity in connecting all pulsing test sets. Nearly all units operate with identical principles.

Pulsing Limits Test Set. This test set functions similarly to the telephone test set. It differs in appearance from the previous test set because it has no handset. The pulsing limits test set is strapped to the hand. It consists of a dial, a release switch, a shunt switch, a cord, and a test plug. Monitoring and talking are not possible, since there is no receiver or transmitter. Having inserted the test plug into the MON A jack of the circuit plate at the equipment, you rotate the dial. The pulsing relay of the circuit under test should repeat the dial pulses. Pressing the RLS switch releases the circuit. A depressed shunt switch connects more resistance into the pulsing relay circuit. Following depression of the shunt switch and dialing, the pulsing relay should again repeat the pulses.

By comparing figure 6-3 with figure 6-4, you can see the similarity in design of the test handset and the pulsing limits test set. Operating the dial of this set alternately opens the 1340 ohms resistance circuit between T and R of the plug. You would operate the shunt key to short circuit the 1340-ohm resistor while connecting 10,000 ohms resistance between T and R of the plug. Note that these circuit changes affect the pulsing relay in the equipment, if you have inserted the plug into the equipment test jack.

Exercises (646):

1. You notice that a selector switch is stepping erratically. Indicate the following:
   a. The piece of test equipment you would use.

b. The type of PMI you would perform.

c. The reason you would approach the problem in this way.

2. Specify when, other than for PMI purposes and for the purpose of checking adjustments that were made, you would use an XY switch test.

3. Clarify when the circuit plate maintenance would be used in troubleshooting.

4. State what type(s) of routine(s) the XY switch test set is/are used for.

5. Cite what type of PMI would you perform if a linefinder is stepping erratically, and what piece of test equipment you would use.

6-2. Call Tracing

Throughout this volume, the similarities of the Strowger system and the XY system have been called attention to repeatedly. In this section again the similarities, and there are many, are mentioned and the differences compared.

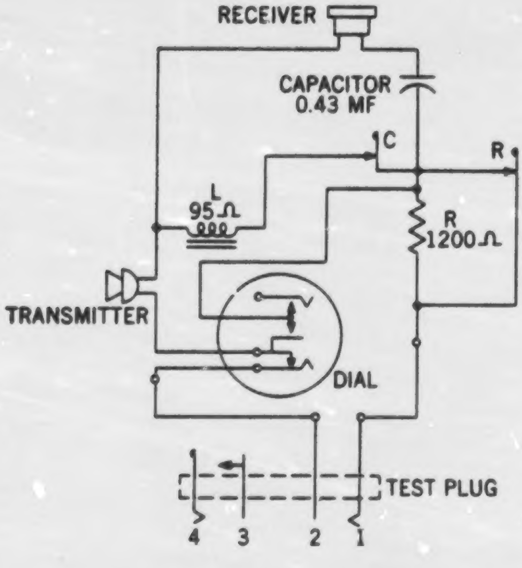


Figure 6-3. Schematic diagram of test telephone circuit.

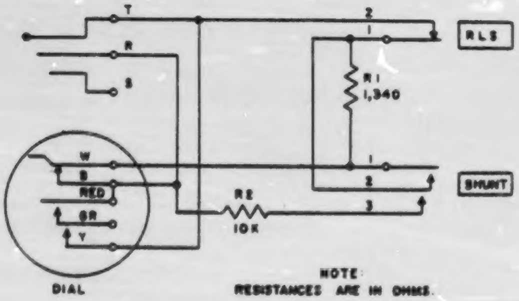


Figure 6-4. Schematic diagram of pulsing limits test set circuit.

647. Using figures 6-5 through 6-11 as required and given representative call tracing situations, identify all necessary actions and sources of information needed to determine the called or calling number and, supplied with typical shelf designation cards, interpret selected significant information correctly.

The XY central office equipment is connected or trunked in the same way as is a Strowger office. Thus there is no need to go into the fact that a linefinder is connected back-to-back with the first selector, etc.

GTA. One difference we do need to mention lies with the grading terminal assembly (GTA). It serves the same purpose and functions that the DTA does in a Strowger office. There are outgoing trunks, DTA has. What, then, is the difference? Just this: The GTA uses four conductors per trunk instead of the three on a DTA. Specifically, the conductors used on a DTA are T, R, and C; whereas those on a GTA are T, R, S, and HS. As a point of information, though, this extra conductor does not affect a thing so far as the purpose or function of the GTA is concerned.

OGT NUMBERS, OGT TERMINAL BLOCKS,
AND SOME TYPE OF GRADING THE SAME AS

Determining the Subscriber's Telephone Number. In this area, the XY system is superb. Having a 100-point system, it is easy to understand. For example, the location of the flange of the pinion gear, with respect to the guide rule, tells you what the TENS digit of the number is. Likewise, the digit on the digit drum, just above the guide rule, tells you the UNITS digit of the number. The number group is normally stencilled on the linefinder and connector shelf frame as well as on the door of the switch cell.

From Here to There and Back. Now we find a difference: the XY switches do not have individual switch tags, as exist in the Strowger office. So a shelf of switches, linefinders, selectors, or connectors has a shelf designation card.

These cards mount in card holders or are glued to

	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	20
	31	32	33	34	35	36	37	38	39	30	41	42	43	44	45	46	47	48	49	40
	51	52	53	54	55	56	57	58	59	50	61	62	63	64	65	66	67	68	69	60
	71	72	73	74	75	76	77	78	79	70	81	82	83	84	85	86	87	88	89	80
	91	92	93	94	95	96	97	98	99	90	01	02	03	04	05	06	07	08	09	00

SW										
SW										

Figure 6-5. Blank shelf designation card.

the inside of the switch cell door as indicated on the method of assembly for the individual shelves.

A blank shelf designation card is shown in figure 6-5. Information, peculiar to the installation, is entered by engineering-installation personnel when the system is installed or modified.

Linefinder shelf designation card. Each 100 linefinder shelf has one card. Figure 6-6 shows sample entries for the right-hand part of the card. Notice that the bay number shelf letter of equipment is given in the title block. In the rows to the right of SW, the number of the linefinders in the shelf are entered. Under each finder number, on the lines IS SEL and IN BAY, are found the first selector circuit number and the bay number to which the finder is cross-connected.

In the left-hand portion of the card, the printed numbers refer to the bank terminals on the finder shelf. Under each linefinder bank terminal number, the connector bank terminal number and shelf number are found. In an office without a line IDF, the lines of one finder group will normally be connected to the terminals of an associated connector group by straight strapping on the auxiliary terminal block of the connector shelf. Thus, line 11 is strapped to connector terminal 11, line 12 is strapped to connector terminal 12, etc.

The left-hand portion of the linefinder card may look like the example shown in figure 6-7.

Selector shelf designation card. Each group of 10 or 20 selectors has one card. Figure 6-8 shows sample entries for the right-hand part of the card.

The left-hand part of a first selector card will look like that shown in figure 6-9. Under the bank terminal numbers, you will find the appropriate data for the succeeding circuit locations.

Connector shelf designation card. Each connector shelf requires one card 480182. In the right-hand portion of the connector shelf designation card, the connector circuit numbers are entered in the rows marked "SW." Under each connector number, in the

TITLE BLOCK-------------	LINE FINDER-CONNECTOR BAY LC-1 SHELF C									
LINE FINDER SWITCH #----	SW	1	2	3	4	5	6	7	8	9	10
FIRST SELECTOR #--------	IS SEL	2	12	22	13	4	24	15	6	26	17
IN BAY------------------	IN BAY	101	101	101	101	101	101	101	101	101	101
	SW	11	12	13	14						
	IS SEL	8	28	19	20						
	IN BAY	101	101	101	101						

Figure 6-6. Sample linefinder shelf designation card.

LF BANK TERM--		11	12	13	14	15	16	17	18	19	10	21	22	23	24	25	26	27	28	29	20
CONN BANK TERM SHELF ----------	TERM SH	11 C-1-D	12 C-1-D	13 C-1-D	14 C-1-D	15 C-1-D	16 C-1-D	17 C-1-D	18 C-1-D	19 C-1-D	10 C-1-D										
		31	32	33	34	35	36	37	38	39	30	41	42	43	44	45	46	47	48	49	40
		51	52	53	54	55	56	57	58	59	50	61	62	63	64	65	66	67	68	69	60
		71	72	73	74	75	76	77	78	79	70	81	82	83	84	85	86	87	88	89	80
		91	92	93	94	95	96	97	98	99	90	01	02	03	04	05	06	07	08	09	00

Figure 6-7. Sample linefinder shelf designation card.

TITLE BLOCK ------------	FIRST SELECTOR BAY 101 SHELF A									
SELECTOR SWITCH #-----	SW	1	2	3	4	5	6	7	8	9	10
FIRST LINEFINDER SW---	IS SW	1	1	4	5	7	8	10	11	13	14
ON SHELF---------------	ON SH	A	C	A	C	A	C	A	C	A	A
	SW										

Figure 6-8. Sample first selector shelf designation card.

BANK TERMINAL-----	LEV/ STEP	11	12	13	14	15	16	17	18	19	10	21	22	23	24	25	26	27	28	29	20
SWITCH-------------- SHELF & BAY--------	SW BAY	61 1010	62 1010	63 1010	64 1010	65 1010	66 1010	67 1010	68 1010	69 1010		1 C-1-8	6 C-1-8	7 C-1-9	8 C-1-8	9 C-1-8	10 C-1-8	11 C-1-8	12 C-1-8	13 C-1-8	14 C-1-8
		31	32	33	34	35	36	37	38	39	30	41	42	43	44	45	46	47	48	49	40
		51	52	53	54	55	56	57	58	59	50	61	62	63	64	65	66	67	68	69	60
		71	72	73	74	75	76	77	78	79	70	81	82	83	84	85	86	87	88	89	80
		91	92	93	94	95	96	97	98	99	90	01	02	03	04	05	06	07	08	09	00

Figure 6-9. Sample first selector shelf designation card.

rows marked *IS TERM* and *SW BAY*, you will find the bank terminal number from which the connector is seized and the switch and bay number of the first switch in the first group of selectors having access to that terminal.

The right-hand portion of the connector card will look like figure 6-10.

The left-hand part of the connector shelf card shows the finder bank terminal number and finder shelf number for each bank terminal. Figure 6-11 shows sample entries of this information.

Tracing Calls Forward. Tracing a call through an office in the forward direction is a simple procedure involving only a few definite steps, as follows:

1. Locate the group of lines from which the call was originated.
2. By examining each XY Universal switch in that group, determine which linefinder is stepped to the proper X and Y position to have seized the calling line. *CAUTION:* When checking a switch to determine which level in X it has been stepped to, do not confuse the flange of the pinion gear with the silver portion of the X carriage right next to it. Use the flange (black in color) as a guide.
3. Refer to the shelf designation card associated with this shelf of finders. On the right side of the card, you will find listed the specific selector by bay, shelf, and number which is associated with this finder.
4. Locate the selector and determine the position to which the switch has been stepped. The shelf designation card associated with this shelf of selectors will show on the left side which circuit will be seized from among any of the 100 possible selector positions. This circuit will be identified again by circuit number, shelf, and bay.
5. Locate this circuit which has been seized. If it is

TITLE BLOCK -------	CONNECTORS 3300 GROUP BAY LC-1 SHELF D										
CONNECTOR SWITCH #-	SW	1	2	3	4	5	6	7	8	9	10
IS TERM ------------	IS TERM	21	21	21	21	21	22	23	24	25	25
SELECTOR SW # ------ BAY ----------------	SW BAY	1 101	11 101	21 101	41 101	51 101	1 101	1 101	1 101	1 101	21 101
	SW										

Figure 6-10. Sample connector shelf designation card.

a connector, the connector switch will be stepped out into the wire bank to some position, and reference to the line record cards for that connector group will identify the seized line and give any additional information desired. If the seized circuit is something other than a connector, the shelf designation card will tell where the call has been routed to, and any further tracing will proceed as in previous steps.

Tracing Calls Backward. A person is called upon to trace calls backwards towards the point of origin far more frequently than he is required to trace them in a forward direction. Tracing backwards is accomplished again by following definite simple steps. But some additional thought and precautions are necessary. Here they are:

1. Locate the connector group in which the answering line is located.
2. By examining each switch in that group, determine which connector has been stepped to the proper X and Y position in the wire bank that matches the last two digits of the called party's number.
3. Reference to the right side of the associated shelf designation card will tell you from what selector level this connector may be seized, and the type of selectors involved—1st, 2d, etc. This information, plus the number of the connector, is all you need at this time.
4. Go to the selector shelves, and—one shelf at a time—open the door covering the switches and look at the left side of the shelf designation card. Under the ten sets of, terminals listed which constitute the ten steps in the level from which the connector was seized, look to see whether or not the specific connector number appears. If it does not appear, this means that it could not have been seized from this shelf of selectors. In that case, you can close the door and go on to another shelf. If, however, the number of the connector does appear, note what exact wire bank position, and particularly which Y step the selector switch would have to be stepped to in order to seize that connector. Inspect all switches within this shelf or split shelf to determine whether or not any one of them has been stepped to the proper position. If you find one, it is the one used in the placing of this call. If no switch is found in the proper position, go on to the next shelf. Again, refer to the shelf designation card (left side) and repeat the previous steps. You will sometimes notice that the position to which a selector must step to seize a given circuit will vary from shelf-to-shelf. This is due to the methods of connection, or multiplying wire banks, that were discussed earlier. For this reason you must always refer to the card associated with the selector shelf in which you are looking. In one of the shelves, you will find the selector that you are seeking.
5. Refer to the right side of the selector shelf card. There you will find the specific circuit—identified by number and location—which seized this selector; that is, if the preceding circuit is a linefinder. In this case, locate the specific linefinder and determine what line it has hunted to complete the tracing of the call. The line record cards again may be used to determine who is on the line, etc.
6. If the call went through the 1st and 2d selectors, however, it will be necessary for you to locate the 1st selector used before you can locate the linefinder. Therefore, after locating the 2d selector as you did in step 4, it will be necessary for you to once again refer to the shelf designation card on the right side and determine from which 1st selector level this specific 2d selector was seized. Then repeat step 4 exactly, until you have located the 1st selector used on the call. Once you have located this, you would proceed, as in step 5,

CONNECTOR BANK TERMINALS		11	12	13	14	15	16	17	18	19	10	21	22	23	24	25	26	27	28	29	20
LINEFINDER BANK TERMINALS LINEFINDER SHELF	TERM SH	11 LC-1C	12 LC-1C	13 LC-1C	14 LC-1C	15 LC-1C	16 LC-1C	17 LC-1C	18 LC-1C	19 LC-1C	10 LC-1C										
		31	32	33	34	35	36	37	38	39	30	41	42	43	44	45	46	47	48	49	40
		51	52	53	54	55	56	57	58	59	50	61	62	63	64	65	66	67	68	69	60
		71	72	73	74	75	76	77	78	79	70	81	82	83	84	85	86	87	88	89	80
		91	92	93	94	95	96	97	98	99	90	01	02	03	04	05	06	07	08	09	00

Figure 6-11. Sample connector shelf designation card.

to identify the linefinder used and the originating line which it stepped to.

Tracing calls is best practiced by setting up calls in the office and tracing first forwards, then backwards; so that you will be ready when an actual call must be traced.

Exercises (647):

1. Give the major difference between a DTA and a GTA.

2. State what the left-hand side of a shelf designation card for a selector shelf represents.

3. Specify what information is contained in the left-hand side of a shelf designation card for a selector shelf.

4. Name the next switch in line, when you find the calling party's number in linefinder switch 12. Use figure 6-6 as necessary.

5. You are tracing a call backward from the connector switch. You are at selector switch 3, and it is stepped X-2 and Y-9. Using figures 6-8 and 6-9 as necessary where do you go next?

6. What is the next switch in the switch train, when tracing a call forward in the above problem?

7. You have been asked the next switch in the switch train, when the called party's number is found in connector switch 8 of bay LC-1, shelf D. Using figures 6-10 and 6-11 as necessary, what do you do?

Answers for Exercises

CHAPTER 1

Reference:

600 - 1. 280.

600 - 2. 3000 line circuits.

600 - 3. Tip, ring, and SN.

601 - 1. PA, YS, XS, YD, GD, SA, FB, PU, AS, and TF are relays in the XY allotter circuit.

601 - 2. Allotter A transfers its functions to allotter B.

601 - 3. X, Y, and X (release) magnets.

601 - 4. Tip, ring, sleeve, HS, X, and XX.

602 - 1. Relay ST in allotter B will operate.

602 - 2. Closed.

602 - 3. The linefinder automatically searches for marked terminals.

602 - 4. Terminal 7 in the X bank for the 71-70 circuit plate in the 600-linefinder group bay is grounded.

603 - 1. Relays LR and CO on circuit plate 5 for the first bay operate when the telephone handset at station 48 is lifted.

603 - 2. Relay CO.

603 - 3. Ground from the sleeve (S) lead keeps the CO relay operated.

604 - 1. The called subscriber's replacement of the handset opens connector relay circuits. They, in turn, disconnect ground from the SN lead which restores the line circuit CO relay.

604 - 2. You connect ground to the line circuit-linefinder bank HS lead to restrict service for the associated telephone.

605 - 1. Terminal 8 at the busy switch.

605 - 2. These are as follows:
a. SA
b. GD
c. ST
d. YD

605 - 3. Contacts 9 and 10 of relay SA and 29 and 20 of relay GD, terminals 6, 11 and 16 of circuit plate C jack and plug, contacts 27 and 28 of relay TF, leads ST-B and AST, terminals 20 and 24 of shelf plug A and circuit plug jack, and contacts 1 and 2 of line circuit relay CO.

605 - 4. Line circuit relay LR and allotter relay GD.

605 - 5. Allotter relay GD (operated) and allotter relay XS (released).

605 - 6. Relay PA.

606 - 1. Contacts 9 and 10 and 6 and 7 of relay ST, 6 and 7 of Y off-normal springs, 26 and 27 of relay YD, 2 and 3 of relay PA, 7 and 8 of relay GD and 11 and 12 of relay SA.

606 - 2. The ground potential for operating the allotter XS relay is connected to the X-XX bank terminal by the operated line relay in line circuit 7 for the specific group.

606 - 3. Relays SA, GD, PA, and XS.

607 - 1. The magnet interrupter springs.

607 - 2. Relays GD and YD.

607 - 3. Contacts 26 and 27 of Busy and Reset switch and 9 and 10 of relay YS and terminal 9 of C circuit plate jack and plug.

608 - 1. Terminals 7, 25 and 29 of A circuit plate jack and shelf plug, contacts 3 and 4 of relay ST, 31 and 32 of relay SW, and contacts 3 and 4 of the X and Y magnet off-normal springs.

608 - 2. A linefinder release failure lights a RLS lamp to indicate the problem.

608 - 3. During an XY linefinder release, electrical circuits are opened which operate mechanical devices. The mechanical devices, in turn, open electrical circuits.

609 - 1. When all linefinders in an XY telephone switching center group are busy, contacts 6 and 5 of relay FB in each allotter complete the operating circuit to the ST leads of the common supervisory circuit. As a result, an interrupter circuit provides audible and visible alarms. These alarms are in operation approximately 2 minutes after the FB relays are released.

609 - 2. A 10-impulse-per-minute signal operates an ATB meter to register the linefinder busy condition following the circuit connection at contact 22 of relay FB.

610 - 1. Relays, PU, AS, and TF.

610 - 2. The linefinder AST leads are transferred to the second allotter's terminals.

611 - 1. When trouble develops in an allotter, relay TF transfers the AST leads to the second allotter.

611 - 2. A transfer lamp is lighted while one allotter is serving all linefinders.

611 - 3. Contacts 23 and 24 of relay AS complete the operating circuit for the allotter transfer lamp.

612 - 1. Since there is only one report of this trouble, it appears that the fault must be in the line circuit, which serves only the one telephone. For the telephone to receive dial tone from the X-Y system equipment, the line circuit LR relay must operate to, in turn, operate the CO relay. The operated CO relay then connects potentials to the S and AST leads of the linefinder, so that this equipment can extend the line to the selector for reception of dial tone. Accordingly, the trouble could be either a defective LR or CO relay or the contacts for either relay. You correct the trouble by

checking the relays for continuity or by cleaning and adjusting their contacts.

612 - 2. Relay SW in a linefinder circuit plate and relay YS in an allotter circuit plate are possible troubles when this trouble symptom is reported. In addition, defective T, R, S, or HS wipers would provide this symptom. Of course, this trouble symptom should normally be on the report of a test man, because the subscriber should be served by the associated linefinders in the group. One method for correcting the trouble is for you to operate the test switch of the allotter circuit plates and observe the stepping action of the associated XY switches to isolate the faulty linefinder of the linefinder group. Then, inspect those devices considered probable faults and maintain them as indicated in the system trouble chart.

CHAPTER 2

613 - 1. Selectors are connected in multiple.
613 - 2. The subscriber must dial a digit following reception of dial tone.
613 - 3. Time is required for a selector to step the equipment and make the mechanical connections.
613 - 4. Selectors may be referred to as incoming, second, third, reverting call, special, intercept, digit canceling, etc.

614 - 1. Ground.
614 - 2. The selector steps in the X direction in response to dial pulses.
614 - 3. The negative potential on the S lead comes from the HA relay battery connection.
614 - 4. Relay SW does not operate until after Y direction stepping is completed, because it is shunted by ground on the S lead or because the XY overflow springs open its operating circuit.

615 - 1. A dialed digit is required to move the switch in the X direction; whereas the switch moves in the Y direction automatically.
615 - 2. Relays CB, RD, and XD operate during seizure of the XY selector.
615 - 3. Contacts 23 and 25 of relay XD connect dial tone to the calling telephone line.

616 - 1. Relay CB and the X magnet operate alternately to step the XY switch in the X direction.
616 - 2. By observing the selector circuit MON lamp, you can determine whether or not the selector is stepping.
616 - 3. Negative potential for the X magnet is provided by terminal 7 at the circuit plate plug.

617 - 1. Ground potential on the selector S wiper continues the XY switch stepping the Y direction.
617 - 2. An idle connector is indicated when the S wiper encounters an absence-of-ground on an S bank contact. The selector will switch through to this connector following this connection.
617 - 3. Relay HA and the Y magnet operate alternately to step the XY switch in the Y direction.

618 - 1. The XY switch overflow springs make to complete a busy tone circuit to the calling subscriber. Then, following telephone handset replacement, relays CB and RD release, and the Z magnet operates and releases.
618 - 2. Relay SW contacts 23 and 24, 26 and 27, relay XD contacts 23 and 24 and contacts 7 and 8 of the XY overflow springs complete the selector busy tone circuit.

619 - 1. Relay SW operates and relays CB and RD releases.
619 - 2. Contacts 1 and 2 of Z magnet, 1 and 2 of Y magnet, 4 and 5 of XY overflow, 5 and 6 of Y off-normal, 5 and 6 of X-off-normal, 5 and 6 of relay HA, 21 and 22 of relay XD and 5 and 6 of relay RD.
619 - 3. Contacts 27 and 28 and 29 and 30 of relay SW in linefinder and 24 and 25 and 27 and 28 of relay SW in the selector extend the subscriber line to the connector.

620 - 1. The XY connector removes ground from the S lead to the preceding equipment to restore it to normal.
620 - 2. In the selector, relay SW, magnet Z, and the XY switch release following completion of the call.

621 - 1. Level restriction wiring controls subscriber access to XY telephone system equipment.
621 - 2. The monitoring jack and lamp aid test men when checking XY system telephone equipment.
621 - 3. Series connected resistors and capacitors which bypass high voltage potentials to ground reduce arcing at telephone circuit contacts.

622 - 1. Since the MON lamp is not to be lighted when the selector is idle, we can assume that it never has released. Hence, you should look at the contacts at the Z magnet to see whether or not contact 4 is released from connection with contact 5 and whether or not contacts 1 and 2 are made. We are assuming that the problem is mechanical failure of these contacts at the release magnet.
622 - 2. Since the dial tone circuit includes made contacts of relay XD, we know that relays CB, RD, and XD are functioning. The probable troubles are the selector switch magnets, the SW relay and defective wipers for this selector. Visually inspect and clean the contacts for these units in an effort to correct the trouble.

CHAPTER 3

623 - 1. Trunk hunting and PX connectors are two XY system connectors.
623 - 2. Connectors provide battery (dc) potential to the subscriber telephones.

624 - 1. Relays CB, RT, and XD.
624 - 2. Ground. Operated contacts 1 and 2 of relay CB and 3 and 4 of relay SW.
624 - 3. Relay CB.

625 - 1. Dialing a digit at the calling subscriber's telephone steps the XY system connector in the X direction.
625 - 2. Relay RT.
625 - 3. It disconnects dial tone (for 100-line system) and stops ringing current from operating the called telephone bell.

626 - 1. Digit 4.
626 - 2. Contacts 1 and 2 of relay XD, 23 and 24 of relay RD, 3 and 4 of relay CB and 3 and 4 of magnet Z.
626 - 3. Four times.
626 - 4. Relay BT operates if the called station is busy; whereas relay SW operates if the called station is idle.

627 - 1. Terminal 4 of circuit plate plug and jack and contacts 3 and 5 of relay XD.
627 - 2. Contacts 3 and 4 of relay XD, 6 and 7 of relay BT and 1 and 2 of relay RD.
627 - 3. Contacts 1 and 2 of relay BT, 23 and 24 of relay XD and 11 and 12 of relay SW.
627 - 4. Relay CB releases, RD releases, BT releases and the Z magnet releases.

628 - 1. Relay XD.
628 - 2. He receives ringback tone from the connector while the called telephone is being signaled.
628 - 3. Relay RT.
628 - 4. Relay AB.
628 - 5. Relays AB, CB, RD, RT, and SW.
628 - 6. Relay CB.

629 - 1. When the calling station disconnects first, XY connector relays CB and RD release, and relays AB, RT, and SW remain operated until the called station disconnects.
629 - 2. When the called station disconnects first, XY connector relay AB releases, and relays CB, RD, RT, and SW remain operated until the calling station disconnects.

630 - 1. When the subscriber reports that the called telephone doesn't ring and you relate it directly to a trouble in the connector, the components to consider are the generator's connection to the connector, relay RT and contacts 3 and 4 and 6 and 7 of relay RT, 7 and 8 and 23 and 24 of relay SW and the T and R wipers for the connector. Of course, additional relays must operate contacts, so that relay SW can operate. For example, relay RD must operate contacts 1 and 2, and relay CB must operate 4 and 5, so that relay RD may operate. Hence, you must test the relays of the suspect connector and readjust them as indicated.
630 - 2. The symptom of connector fails to trip, ringing is noted while routinely testing the system. You know that the RT relay's function is to stop the ringing following the called telephone user lifting the handset. Looking at FO 6, you can see that contact 6 must break from contact 7 when the relay operates. If it doesn't, ringing current continues to be heard. Yet, the trouble could also be that relay RT didn't operate to open contacts 6 and 7. Again, we recognize that additional relays in this connector must operate for this relay to operate. To illustrate, contacts 7 and 8 of relay AB and 5 and 6 of the Y magnet complete the RT relay circuit. By inspecting, testing, cleaning and readjusting specific relay and switch components, you overcome the trouble symptoms caused by connector faults.

CHAPTER 4

631 - 1. The emergency and the nonemergency alarms.
631 - 2. These are the:
a. Audible.
b. Visual.
631 - 3. Power panel.
631 - 4. Clear.
631 - 5. Power panel.
631 - 6. *a.* 0 time.
b. 0 time.
c. 3-9 seconds.
d. 0 time.
e. 2-4 minutes.

631 - 7. For alarm indications from the XY dial switching equipment, powerboard, relay racks, attendants' switchboard and the main distributing frame.
631 - 8. Common supervisory equipment is located in the powerboard.

632 - 1. Supervisory lamps, interrupter, ringing and tone equipment.

633 - 1. A fuse that furnishes current to more than one circuit is classified as a common fuse, and a fuse that furnishes current to an individual circuit is an individual fuse.
633 - 2. The row supervisory lamps will indicate either the right or left side of the row.
633 - 3. The low-voltage relay monitors the exchange battery voltage. If the battery voltage drops below 45.5 volts, an alarm is activated to indicate this condition.

633 - 4. The purpose of the release alarm is to indicate to the maintenance man that a switch has failed to mechanically release.
633 - 5. *a.* Nonemergency lamp extension alarm.
b. Fuse alarm common supervisory lamp.
c. Fuse alarm group supervisory lamp.
d. Fuse alarm row supervisory lamp.
e. Fuse alarm shelf supervisory lamp.
633 - 6. *a.* Emergency lamp extension alarm.
b. Fuse alarm common supervisory lamp.
c. Fuse alarm group supervisory lamp.
d. Fuse alarm row supervisory lamp.
e. Fuse alarm shell supervisory lamp.
633 - 7. The operator will depress the audible alarm cut off key and notify the responsible maintenance personnel.
633 - 8. The only relay under control of the alarm cut-off key is CO.
633 - 9. There will be no alarms. If the bad switch is in a linefinder shelf, the allotter will automatically step across it. If it is in a selector shelf or connector shelf, the subscriber will hang up and access a new switch train. This bad switch will be identified on a maintenance routine test.
633 - 10. The LV relay will:
a. 46.5 volts.
b. 45.5 volts.
633 - 11. During a low-voltage condition relays LV, VA, and VB will pulse.
633 - 12. The failure of a heat coil will produce an emergency alarm. However, it is a nonemergency condition.
633 - 13. The failure of an individual fuse will produce a nonemergency alarm.
633 - 14. It is possible to have shelf, row, group and common supervisory equipment involved in an emergency alarm.

634 - 1. The alarm check key, which is a locking key, has been operated to silence the alarm, and was not restored. This trouble could be prevented by using the alarm cut off key instead of the alarm check key to silence the buzzer.
634 - 2. The alarm check key has a pair of open contacts, contacts 3 and 4 of the CO relay are open, or the buzzer is open. Clean the contacts or replace the buzzer.
634 - 3. Obviously the office battery voltage is normal. Therefore, the low-voltage alarm is malfunctioning. A possible cause could be that the calibrate key was left operated, and resistor R1 is set below the operating level of relay LV. Relay LV could also have an open winding. Relay VA or contacts 3 and 4 of VB could also be open. Resistors R1, R2 or P1 could become open and cause the false alarm. Clean contacts, check component parts and replace faulty one.
634 - 4. With DA relay in the common supervisory circuit operated, the DB relay is waiting on a PU pulse, which arrives every 3 seconds. Relay DB is following these pulses. Contacts 3 and 4 of DA or contacts 1 and 2 of DB are dirty and break the hold circuit for DB. Therefore, DC never operates to the ECP Pulse, thus preventing the ground from operating the buzzer. Clean the contacts.
634 - 5. The battery through the broken fuse to the alarm bar and the EF relay and to ground at the fuse at punching 49. The EF relay places ground to the fuse lamp, and the alarm battery is supplied from the discharge circuit

at punching 58, which also operates the E relay to turn on the buzzer. Replace the broken fuse.

634 - 6. Relay SA operates from the emergency start bail initiated from the allotter circuit. SA completes a circuit for SB to operate to the TP1 pulse and lacks up under control of SA. SC should operate when the TP2 pulse arrives. Therefore, the TP2 lead or contacts 1 and 2 of SB are open. Check for the arrival of TP2 pulse, and if it is sent, then clean the contacts.

634 - 7. If the interrupter start key is in the off position, the probable cause would be contacts 3 and 4 of ST ST1 and 5 and 6 of relay DA shorted. Check the start key for proper operation, clean contacts 3 and 4 of the ST relays, and test the winding of DA; if it is shorted, replace it.

635 - 1. The purpose of the discharge and distribution circuit is to supply main battery voltage to the exchange equipment. Its functions include indicating exchange voltage, current charge or discharge, providing direct ground to equipment that is protected, and indicating overload or short conditions.

635 - 2. The purpose of the ringing control circuit is to supply fused ringing current to the exchange equipment. Its functions include operating the subcycle, providing for automatic transfer, and furnishing audible and visual alarms.

635 - 3. The purpose of the interrupter circuit is to interrupt ringing current and provide timing ground pulses to the equipment. Its functions include starting the dc interrupter when it is needed and supplying interrupted ringing and ground pulses.

636 - 1. The ammeter will indicate either. The needle deflection from 0 will show either charge or discharge, whichever is taking place.

636 - 2. Power for the alarms is fed through resistors R3 and R4 to the common supervisory circuit bypassing the main circuit breakers; thus the alarm circuits are assured power for operation.

636 - 3. With the calibrate key operated, the meter will read the voltage being sent out on the − CAL lead to the common supervisory circuit.

636 - 4. The red circuit breaker lamp on the discharge and distribution circuit will be one indication that the common supervisory circuit will have lamps and buzzer also.

636 - 5. The rheostat will adjust the desired voltage range to test low voltage alarm.

636 - 6. R1 and RF1 prevent G1 from chattering on the ringing current.

636 - 7. With both machines out of service, G1 and G2 will be released and TR will be operated. The GEN TRNS lamp will be on, along with the GEN FAIL lamp. Also G2 places ground on the EM lead of the common supervisory circuit, causing an emergency alarm.

636 - 8. The purpose is this—if the ac supply is lost or the subcycle breaks down, a backup machine is needed to provide ringing current.

636 - 9. The RM machine maybe transferred back to the subcycle in two different ways: By operating the RMST and GEN TRNS keys to normal or, if the transfer was automatic, by repairing or restarting the subcycle.

636 - 10. The voltage output of the subcycle is 90 volts at 20 cycle.

637 - 1. The alarm circuit is functioning normal, except for the circuit breaker lamp. Replacing the open lamp should clear the trouble.

637 - 2. If the voltage on the − CAL lead cannot be applied by the calibrate key, the cause could be open R1, R2 or contacts of the CAL key. Replace the resistors or clean the contacts of the key.

637 - 3. This is a trouble transfer, and the subcycle does not have an output. Checkout the subcycle for malfunctions.

637 - 4. The G1 or G2 relay will chatter if the RF is open or shunted. Also they will chatter if the 10K resistor is shorted. Test the parts and replace the inoperative one.

637 - 5. The transfer from the subcycle to the RM machine is incomplete. Contacts 4 and 5 are dirty and relay TR did not operate. Therefore, the output of the RM machine is not being sent through the contacts of relay TR.

637 - 6. This situation is normal, and the dc interrupter will not effect the ac interrupter nor the switching equipment, because relays E and G are not operated.

637 - 7. After an interrupter transfer, relays E and G transfer the ringing and pulses from the ac to the dc machine. It appears that relay G was shorted out and didn't operate.

637 - 8. When the ac machine started, the 120 IPM would not operate BORC relay, which prevented D relay from operating and breaking the circuit to relay F. Therefore, either contacts 25 and 26 or 22 or 23 of the A relay are open. Also, contacts 1 and 2 of B or C relay could be open, or contacts 3 and 4 of relay D are shorted.

CHAPTER 5

638 - 1. The purpose of the XY fire repeater is to provide subscribers a means of calling the fire department.

638 - 2. The purpose of the XY dial-to-dial trunk circuit is to provide your subscribers a way to call directly subscribers in a distant central office and the subscribers in the distant exchange a way to directly call subscribers of your central office.

638 - 3. The purpose of the XY inspector's ringback circuit is to provide the installer repairman with a means of automatically checking the bells of a telephone instrument without calling into the test board.

638 - 4. The purposes of the XY attendant's switchboard and associated circuits are to supplement the automatic services of the exchange and to provide service to the exchange's subscribers.

638 - 5. The XY inspector's ringback circuit is accessed from the banks of the special second selector equipment.

638 - 6. The XY two-way dial-to-dial trunk circuit uses either loop or battery and ground pulsing to repeat the subscriber's dial pulses.

639 - 1. When relay RD in the XY fire repeater operates, it closes ground to the S lead, back to the special second selector to hold it operated, through its 4 and 5 contacts.

639 - 2. The RV relay in the XY fire repeater operates only during operator-assisted fire calls.

639 - 3. The RV relay in the XY fire repeater holds operated to ground through normally made contacts of the DIAL RLS switch.

639 - 4. Note 5, on the schematic diagram (FO 9) of the XY fire repeater, states that the "C" wiring option is used for operator extension of all calls.

639 - 5. The SR relay in the XY fire repeater only operates when the fire department wishes (on unassisted fire calls) the operator to have the call traced. To operate the SR relay, the fire department operates a switch that places ground on the ring (R) side of the line, shunting the ac winding of the SR relay, allowing it to operate.

639 - 6. When the operator pushes the talk key, the OC relay will operate and permit her to monitor the call.

640 - 1. On an incoming call, the first relay to operate in the

XY two dial-to-dial trunk circuit is the PL relay. It operates, without the "W" wiring option being used, through the loop provided by contacts of the RD1 relay and the ac winding of the SR1 relay in the distant exchange.

640 - 2. Contacts 5 and 6 of the SW relay (next to the last relay to release) mark the trunk busy to incoming calls, and because it (SW) releases prior to relays in the other office's trunk circuit (which is marked busy there), the trunk is protected from premature seizure.

640 - 3. On an incoming call, to the trunk circuit, relay SR2 operates when the called party answers. It operates because of the battery reversal in the connector circuit, when the connector's AB relay operates.

640 - 4. When relay CB, in the trunk circuit, operates its 1 and 2 and 3 and 4 contacts partially close the pulsing path to the distant office trunk. Its 6 and 7 contacts close a path to operate relay RD1 in the local office trunk.

640 - 5. Relay SH1, in the trunk circuit on an outgoing call, releases during each dial pause. When it releases, it places a loop through contacts of relay RD1 and the ac winding of the SR1 relay to hold the PL relay in the distant trunk operated until the next digit is dialed or the called party answers.

641 - 1. During seizure of the inspector's ringback circuit, relays CB and RD operate.

641 - 2. The initial function of contacts 3 and 4 of relay RD in the inspector's ringback circuit is to place ground on the back sleeve lead to hold the special second selector switch operated.

641 - 3. When the installer hangs up the first time, the following actions occur in the inspector's ringback circuit:

a. Relay CB releases and closes a path to operate relay SW.

b. Relay SW operates; (1) closing a holding path to relay RD, (2) closing ringing to the ring side of the subscriber's line and ground to the tip side, ringing the phone, and (3) closing a path for a pulsed ground, to operate the RV relay.

c. Ground on the REV G lead operates relay RV, which in turn reverses the ringing. The RV releases and reoperates periodically until the installer goes off-hook.

641 - 4. Without "W" wiring in use, the inspector's ringback trunk releases when the installer lifts the handset. This happens without "W" wiring, because when the RT operates over the subscriber's loop, the ground is removed that holds the preceding equipment operated.

642 - 1. The low-resistance ground on the sleeve of the operator's trunk causes the RHS and RLS relays in the cord circuit to operate; when the answer cord is plugged into the line jack of the trunk.

642 - 2. The purpose of the ground at contacts 1 and 2 of relay CB in the operator's trunk is to provide a hold path for relay SL1.

642 - 3. Contacts 24 and 25 provide a ground on the sleeve back to the preceding equipment to hold the switch train operated.

642 - 4. Three functions accomplished by the SL relay in the operator's trunk are; (1) to operate the SL-1 relay, (2) remove the CB relay from the transmission path, and (3) provide a hold path for the RD relay.

643 - 1. The line jack sleeve, of the operator's trunk circuit, is a low resistance sleeve of 320 ohms.

643 - 2. The main function of the RLS relay in the cord circuit, when operated, is to close the path for the RB relay; which provides transmission battery to the subscriber, when it is in the circuit.

643 - 3. When the call cord is plugged into an out-dial-to-connector jack, the FB relay in the cord circuit is operated. The RHS and RLS relays do not operate because of the open sleeve condition in the line jack.

643 - 4. Relay FB in the cord circuit releases when the AB relay in the connector operates. This happens because of the battery reversal; it shunts the FB relay by using diode B, instead of diode A in series with the ac winding of the FB relay, as the path for current flow.

644 - 1. When wiring option "G" is used in the convertible line it provides for a high-resistance sleeve at the line jack of the switchboard; so that transmission battery will not be provided by the cord circuit.

644 - 2. The convertible line circuit is used as a common battery circuit when the full operate path of the LR relay requires both of its windings.

644 - 3. When a CB subscriber goes off-hook the LR relay in the convertible line circuit operates; causing the line lamp and the busy lamp on the switchboard to light.

644 - 4. When the SL relay, in the convertible line circuit (used as a LB circuit), operates; it closes a path to the CO relay. This happens when the switchboard operator inserts a cord into the line jack of the circuit.

645 - 1. Several sets of contacts in the operator's and position circuit could make it impossible for the operator to monitor calls, the most likely are contacts 24 and 25 of the SW relay; they could prevent the MO relay from operating. Other contacts that could be at fault are 1 and 2 and/or 4 and 5 of the TR relay; 8 and 10 and/or 26 and 28 of the MR relay.

645 - 2. The trouble is most likely that diode A is shorted; this would provide an operate path for relay FB after the battery reversal in the connector. Replacing the diode will correct the trouble.

645 - 3. Contacts 21 and 22 of relay SL1 are shorted; causing relay SL1 to operate at the same time that relay RD operates.

645 - 4. The busy lamp extinguishes when the operator answers the call because contacts 4 and 5 of relay CO are dirty.

645 - 5. The probable reason for this circuit failing to release is that contacts 3 and 4 of relay RD have become shorted. Separating and insulating the contact terminals should clear the trouble.

CHAPTER 6

646 - 1. *a.* For an initial check, the pulsing limits test set or the test handset, preferably the pulsing limits test set, should be used.

b. A type 1 PMI, operational test, should be performed first. Unless it is later found that some adjustment is needed, a type 2 or 3 PMI is not normally a first step.

c. The pulsing limits test set should be used to perform an operational check initially, because the test set is lightweight, requires no special setting up, and will provide a wide range of conditions for testing the selector circuit.

646 - 2. During the troubleshooting of a linefinder, selector, or connector circuit.

646 - 3. The XY circuit plate maintenance test set would be used when it was necessary to more thoroughly check the condition of a circuit than is possible with a pulsing limits test set.

646 - 4. The XY switch test set is used for the performance of type 1 and 2 PMIs.

646 - 5. In this instance, a type 1 PMI of the switch is indicated; this is because the allotter controls the stepping of the switch, not the linefinder circuit. The XY switch test set should be used. There is an excellent chance that a type 2 PMI will have to be performed on the switch.

647 - 1. The major difference between a DTA and a GTA is this: a DTA uses a three-conductor trunk (T, R, and C) and a GTA uses a four-conductor trunk (T, R, S, and HS).

647 - 2. The left-hand side of a selector, shelf designation card represents the 100 bank terminations of the switches in the shelf.

647 - 3. The information contained in the left-hand side of a selector shelf, shelf designation card is this: the switch or circuit number and the bay and shelf location of the succeeding equipment for each of the 100 possible wiper positions of the selector switch wipers.

647 - 4. When you find the calling party's number in switch 12, your next move is to go to selector switch 28 in bay 101, which is the next switch in the switch train.

647 - 5. From selector switch 3 of bay 101, shelf A, when tracing a call backward, to the next switch in line, which is linefinder switch 4 on shelf H.

647 - 6. With switch 3 in the above problem, when tracing a call forward, the next switch in line is connector switch 13 in connector bay 1, shelf B.

647 - 7. When tracing a call backward from switch 8 in the connector bay LC-1, shelf D, you would start in selector bay 101, shelf A and look for a selector stepped X-2 and Y-4.

36251 04 S01 7603

SUPPLEMENTARY MATERIAL

CDC 36251

TELEPHONE SWITCHING EQUIPMENT REPAIRMAN (ELECTROMECHANICAL)

(AFSC 36251)

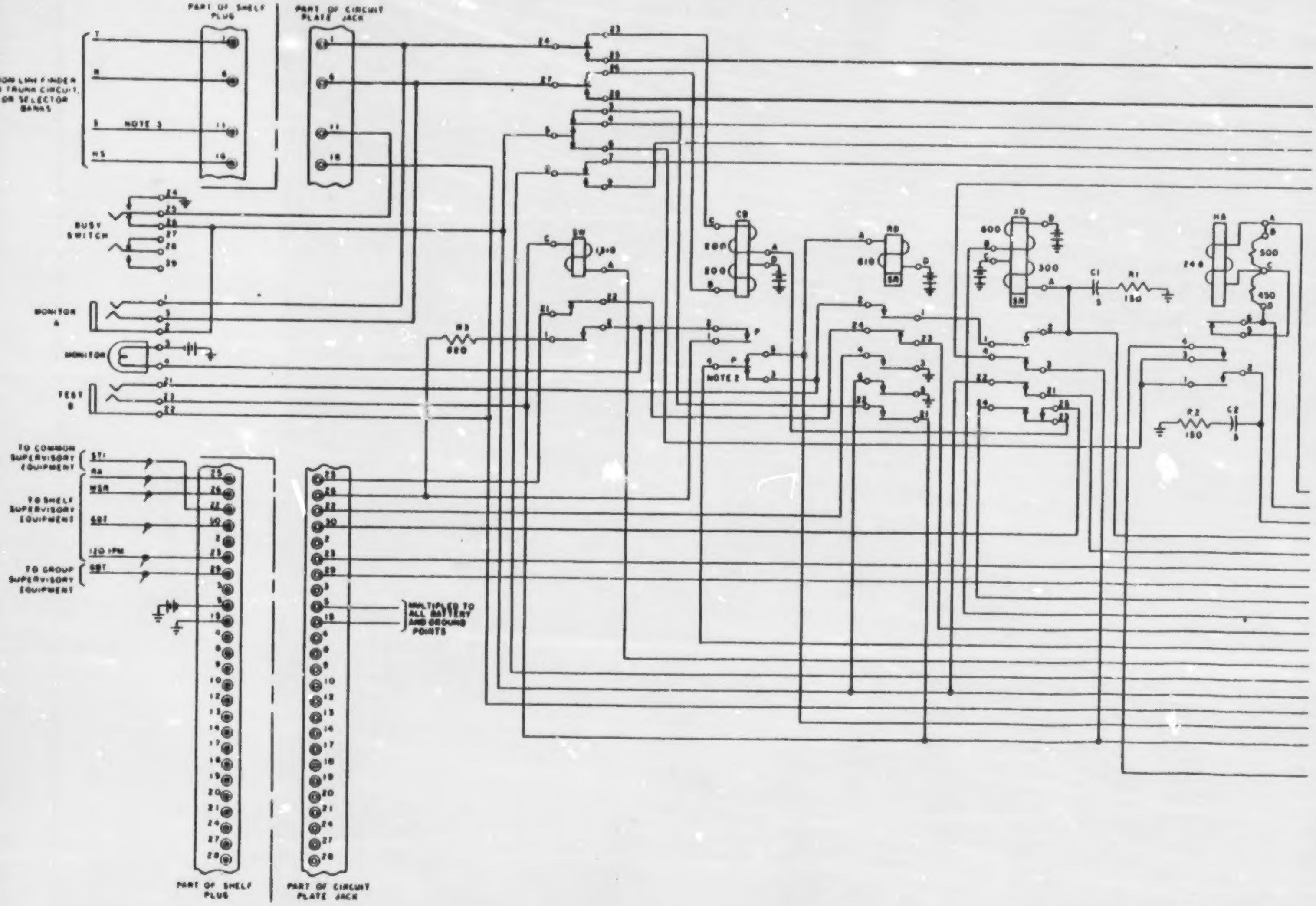
Volume 4

Foldouts 2, 3, 7, 8, 9, 11, 13, 14

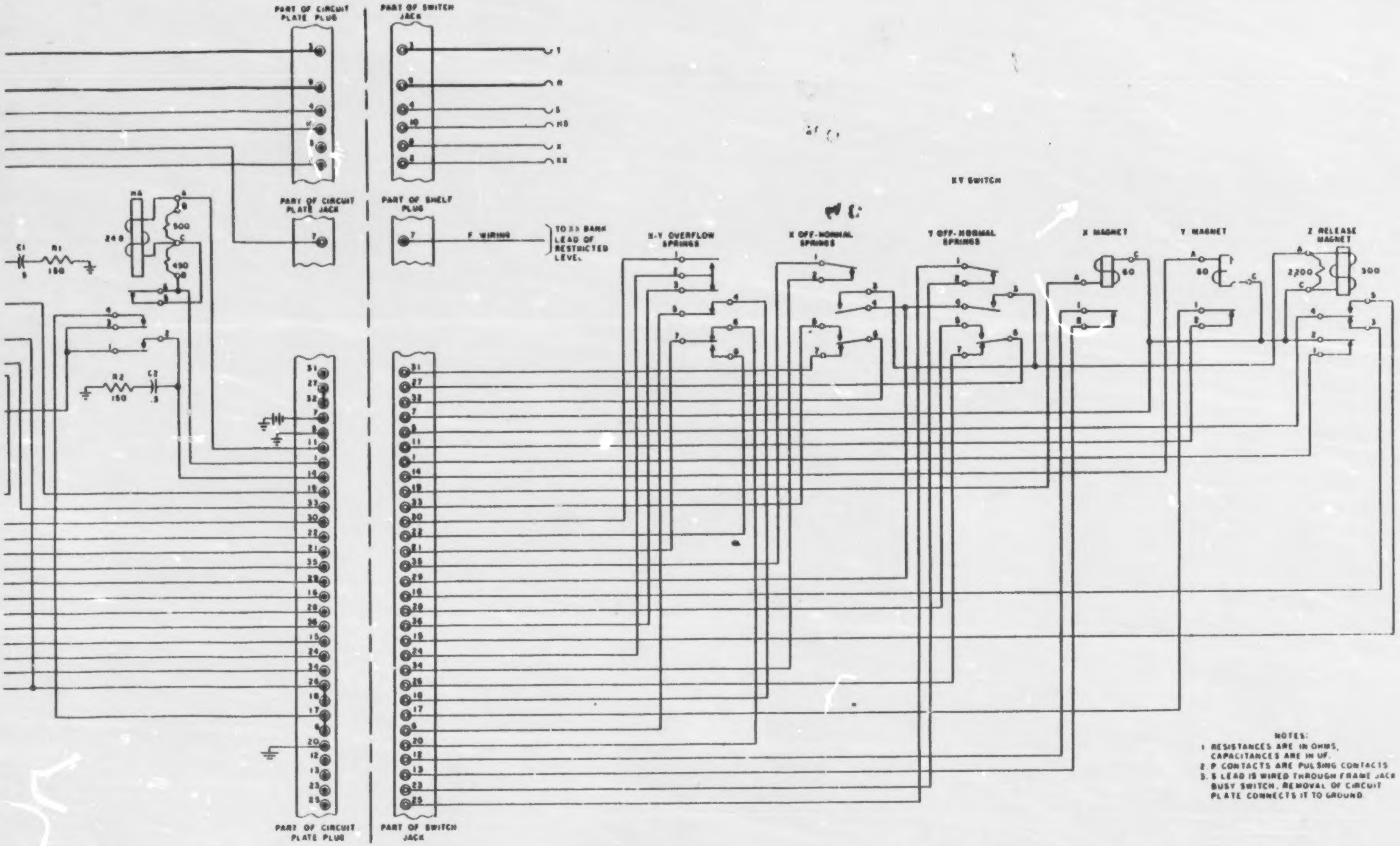
AU GAFS, AL (801037)1100

Extension Course Institute

Air University

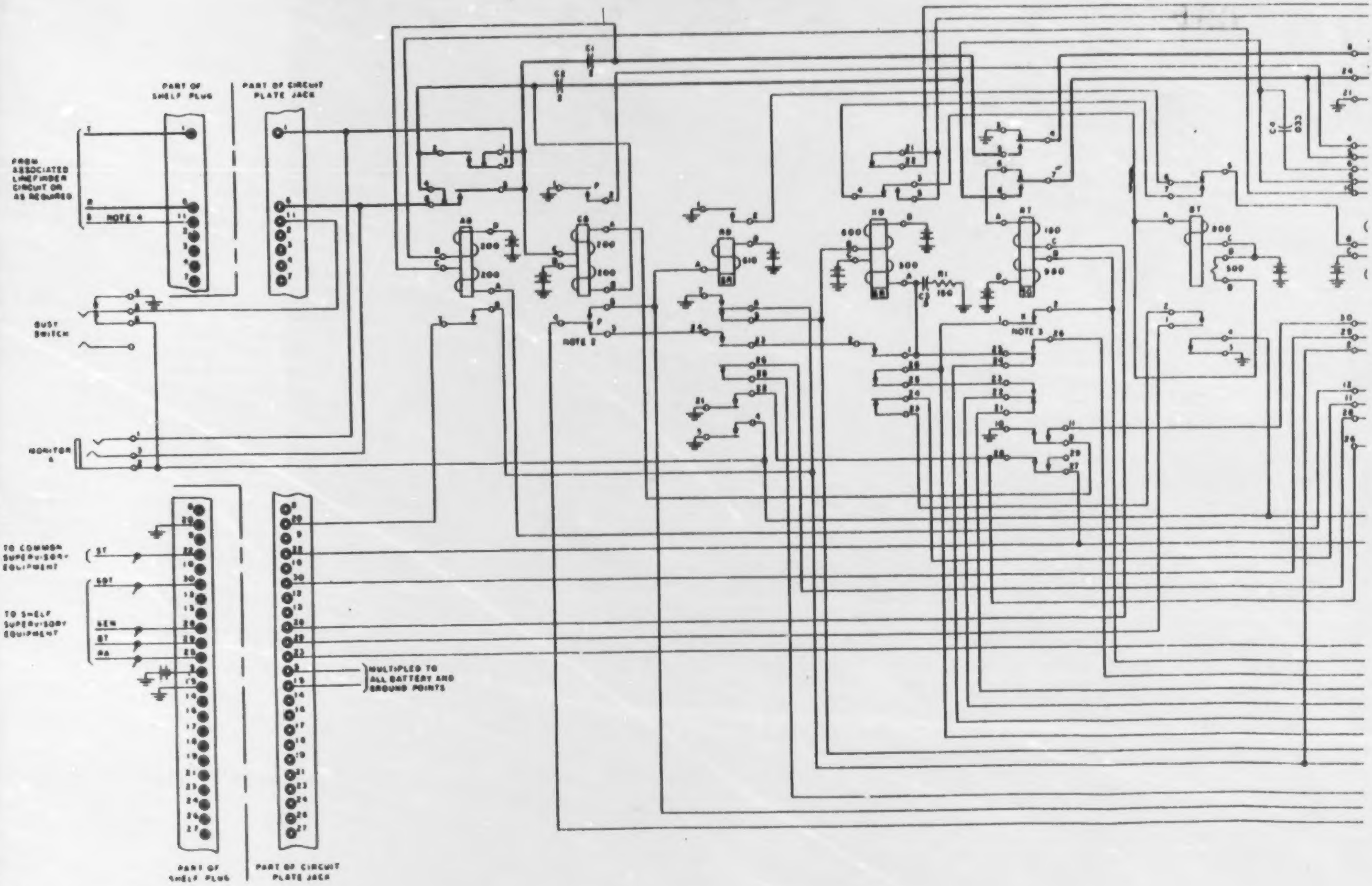

PART OF SHELF PLUG
PART OF CIRCUIT PLATE JACK
FROM LINE FINDER TRUNK CIRCUIT, OR SELECTOR BANKS
T
R
S NOTE 3
HS
BUSY SWITCH
MONITOR A
MONITOR
TEST B
R3 820
SW 1310
CB 800 800
RD 810 SR
XD 600 300 SR
HA 248 500 450
C1 5
R1 150
R2 150
C2 5
NOTE 2
TO COMMON SUPERVISORY EQUIPMENT
STI
RA
MSR
TO SHELF SUPERVISORY EQUIPMENT
GDT
120 IPM
TO GROUP SUPERVISORY EQUIPMENT
GDT
MULTIPLED TO ALL BATTERY AND GROUND POINTS
PART OF SHELF PLUG
PART OF CIRCUIT PLATE JACK

Foldout 2a.

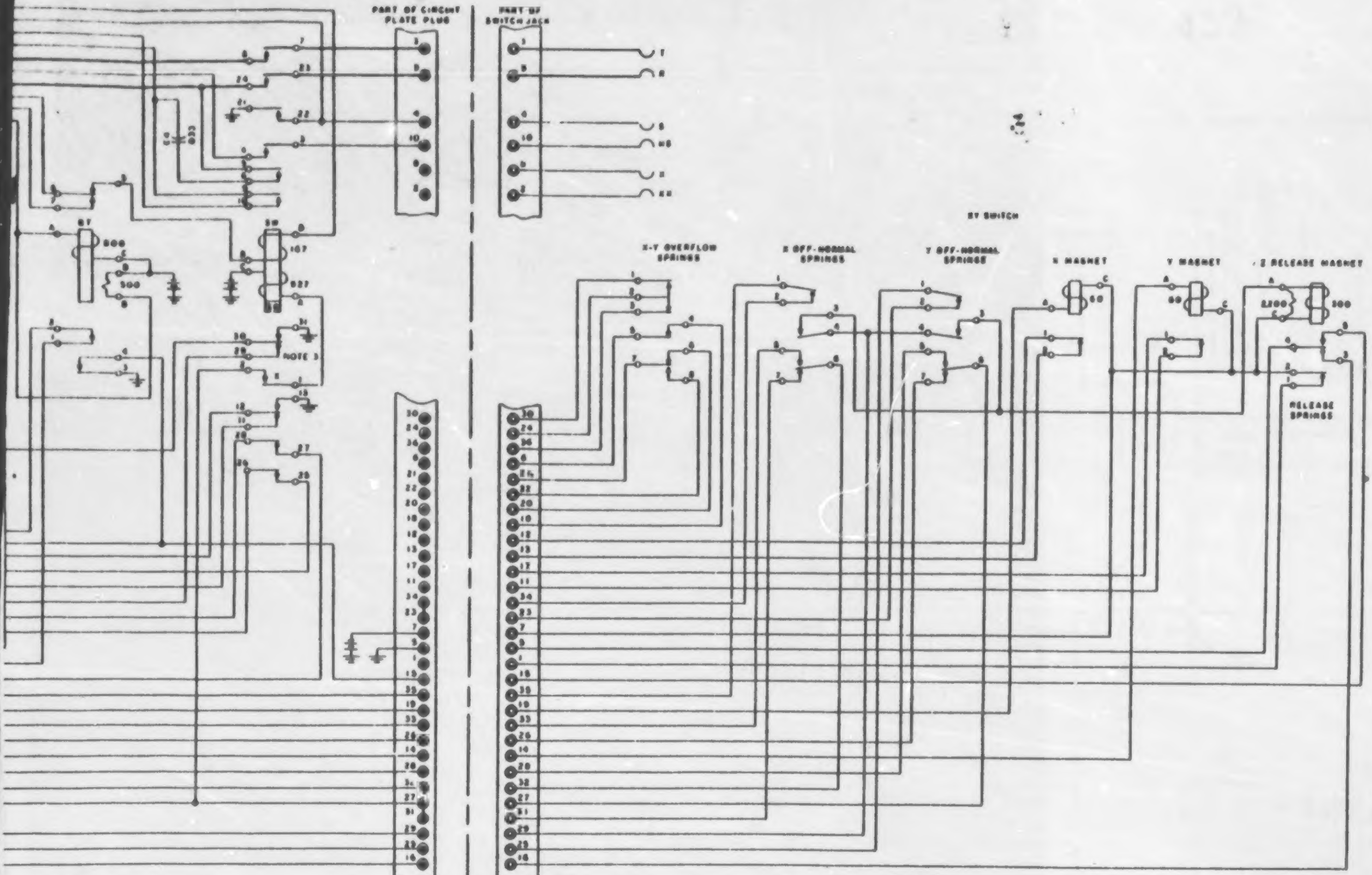


NOTES:
1 RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UF.
2. P CONTACTS ARE PULSING CONTACTS
3. S LEAD IS WIRED THROUGH FRAME JACK BUSY SWITCH. REMOVAL OF CIRCUIT PLATE CONNECTS IT TO GROUND

Foldout 24 XY system selector circuit, nondigit-canceling, schematic diagram

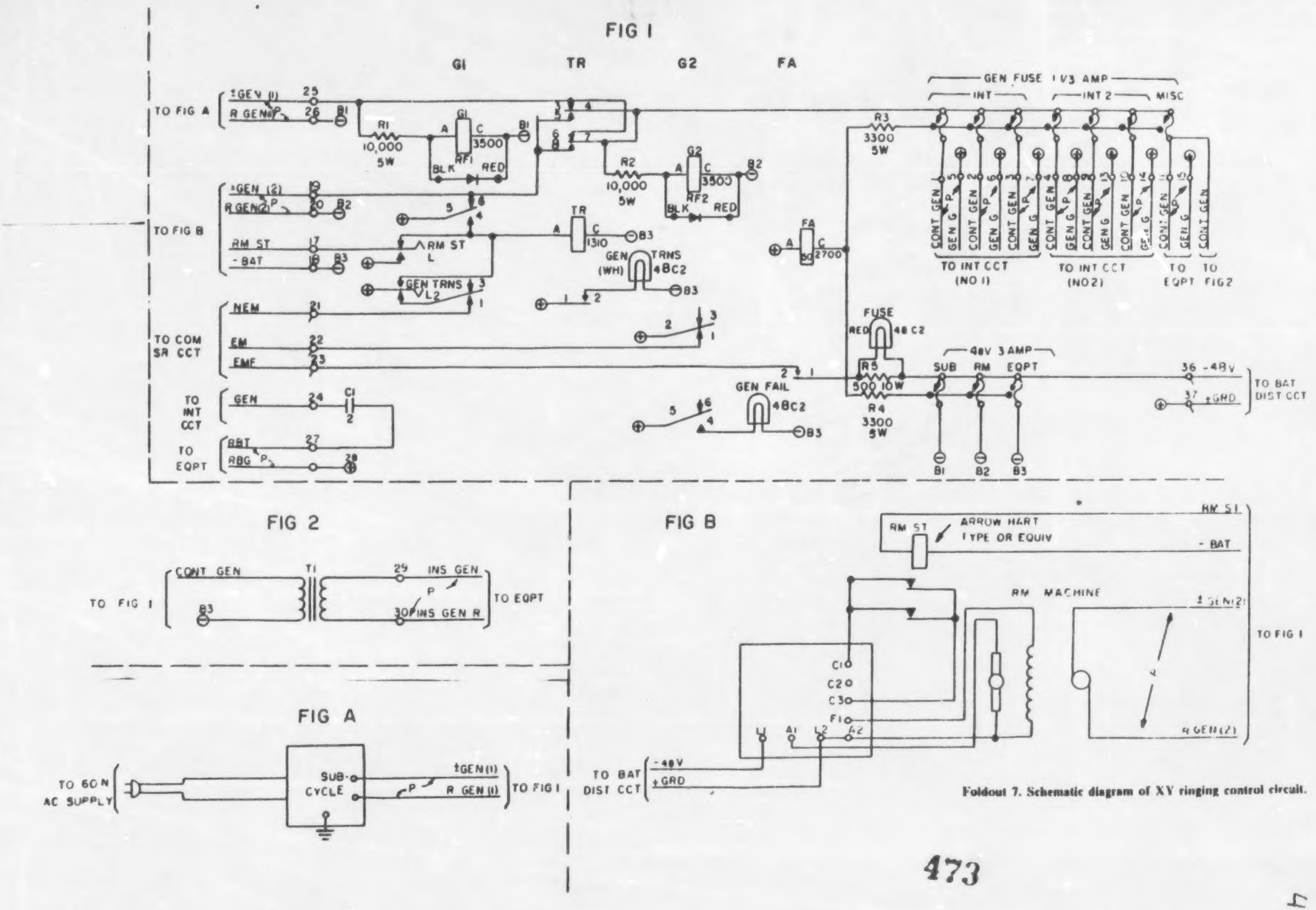

PART OF SHELF PLUG
PART OF CIRCUIT PLATE JACK
FROM ASSOCIATED LINEFINDER CIRCUIT OR AS REQUIRED
NOTE 4
BUSY SWITCH
MONITOR A
TO COMMON SUPERVISORY EQUIPMENT
ST
SST
TO SHELF SUPERVISORY EQUIPMENT
KEN
BT
RA
MULTIPLIED TO ALL BATTERY AND GROUND POINTS
NOTE 2
NOTE 3
C1
C2
C3
C4
R1
AB
CB
RB
SO
RT
BT
200
500
610
600
300
150
950
033
PART OF SHELF PLUG
PART OF CIRCUIT PLATE JACK

Foldout 3a.



NOTES
1 RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UF
2 P CONTACTS ARE PULSING CONTACTS
3 X CONTACTS OPERATE FIRST
4 S LEAD IS WIRED THROUGH FRAME JACK BUSY SWITCH REMOVAL OF CIRCUIT PLATE CONNECTS IT TO GROUND

Foldout 3A Schematic diagram of XY P-X connector.



Foldout 7. Schematic diagram of XY ringing control circuit.

FIG 1

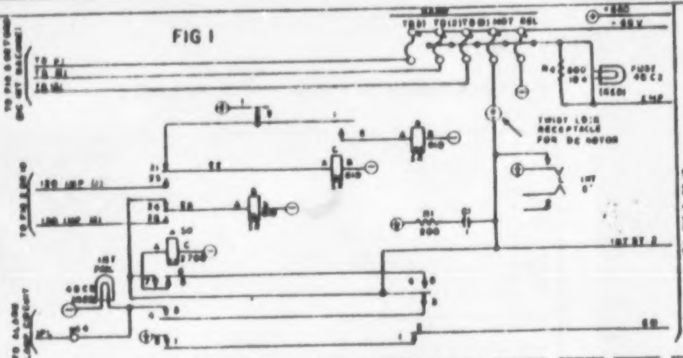
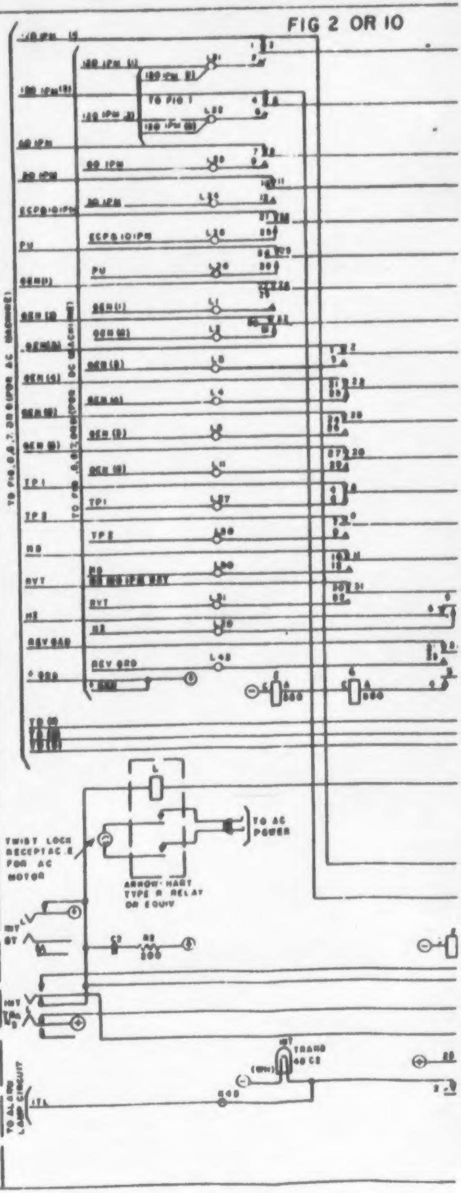


FIG 2 OR 10



TWIST LOCK RECEPTACLE FOR AC MOTOR
ARROW-HART TYPE R RELAY OR EQUIV
TO AC POWER
TO ALARM LAMP CIRCUIT
TP1
TP2
H3
H2
RVT
REV GRD
PU

FIG 3
AC MOTOR

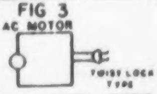


FIG 4

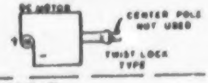
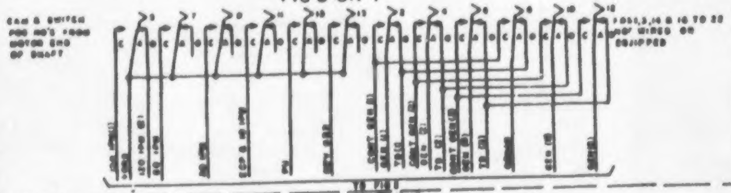


FIG 5 OR 7



CAM & SWITCH POS NO'S FROM MOTOR END OF SHAFT
POS 2,3,14 & 16 TO 22 NOT WIRED OR EQUIPPED

FIG 9

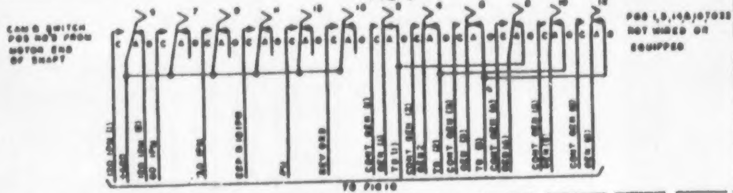
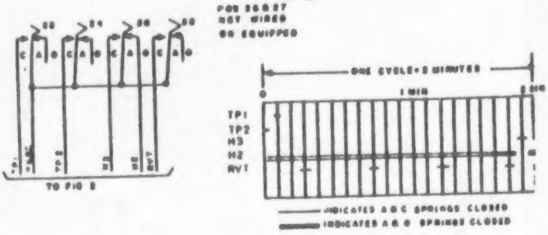
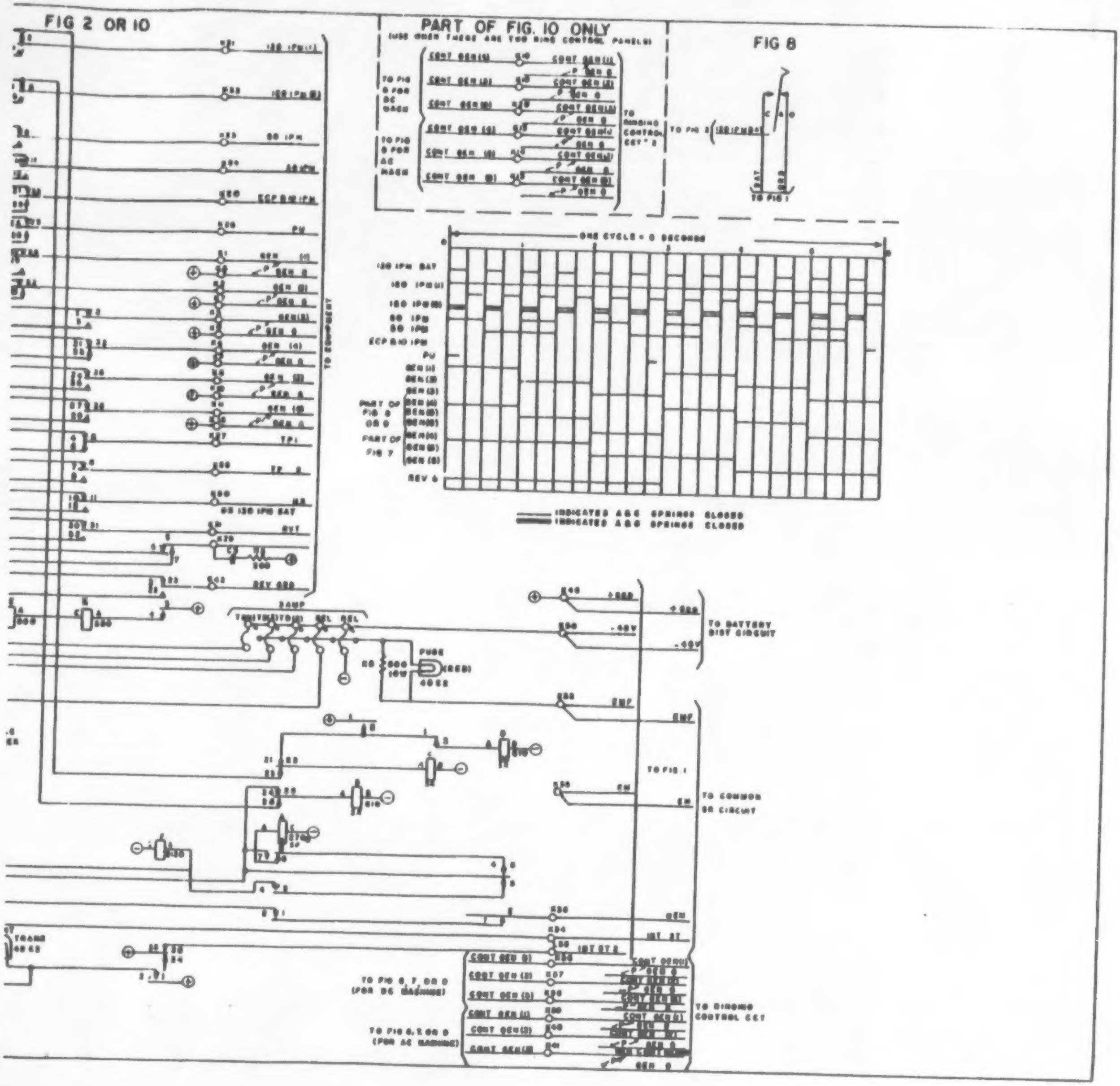


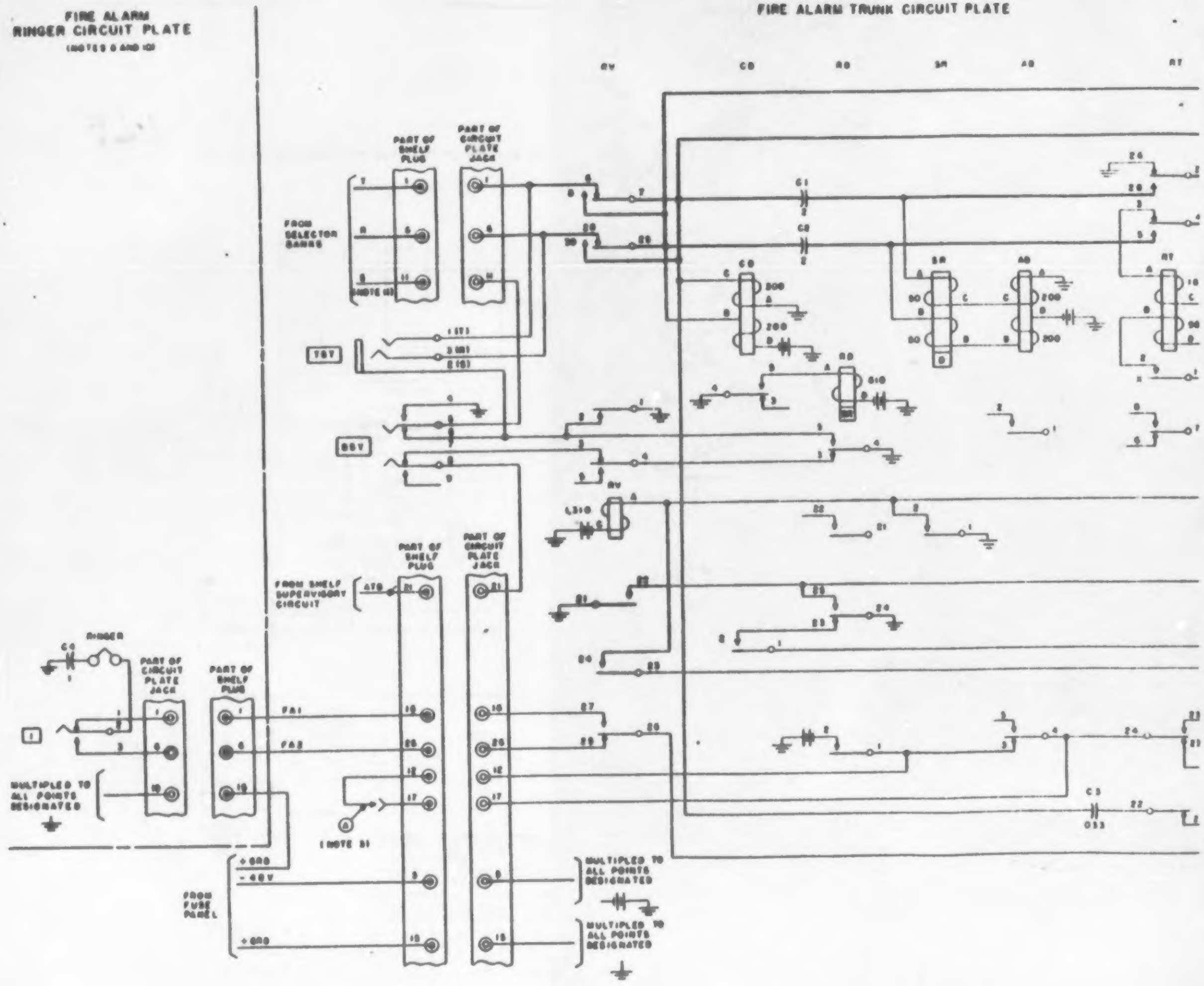
FIG 6



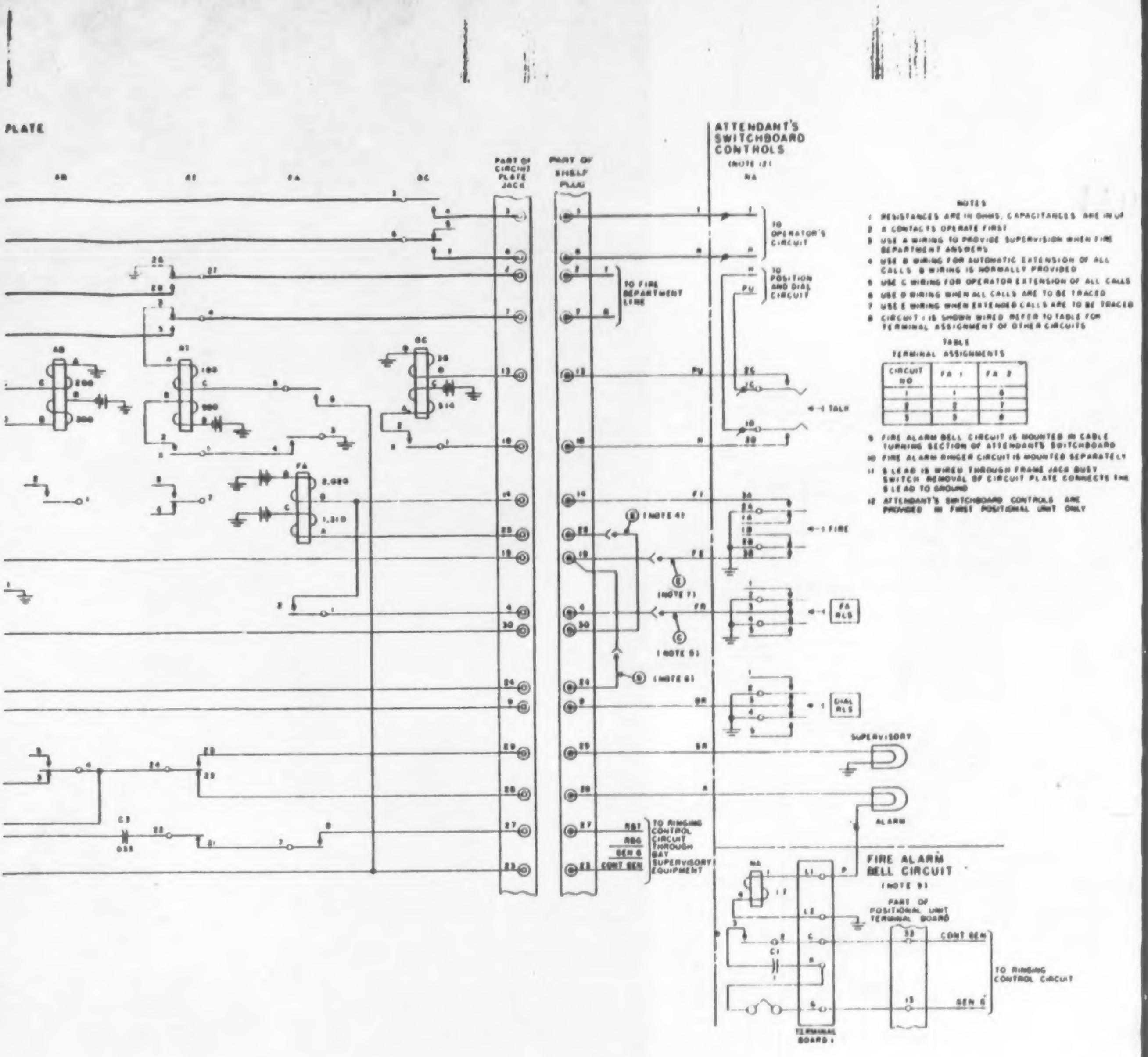
Foldout 8a.



Foldout 8b. Schematic diagram of XY interrupter circuit.


FIRE ALARM
RINGER CIRCUIT PLATE
(NOTES 9 AND 10)
FIRE ALARM TRUNK CIRCUIT PLATE
RV
CO
RO
SR
AO
RT
PART OF SHELF PLUG
PART OF CIRCUIT PLATE JACK
FROM SELECTOR BANKS
(NOTE 11)
TST
1 (T)
3 (R)
2 (S)
BSY
L310
C1
C2
C3
.033
FROM SHELF SUPERVISORY CIRCUIT
ATG
RINGER
C4
PART OF CIRCUIT PLATE JACK
PART OF SHELF PLUG
FA1
FA2
MULTIPLED TO ALL POINTS DESIGNATED
(NOTE 3)
+GRD
-48V
FROM FUSE PANEL
+GRD
MULTIPLED TO ALL POINTS DESIGNATED
MULTIPLED TO ALL POINTS DESIGNATED

Foldout 9a.



NOTES

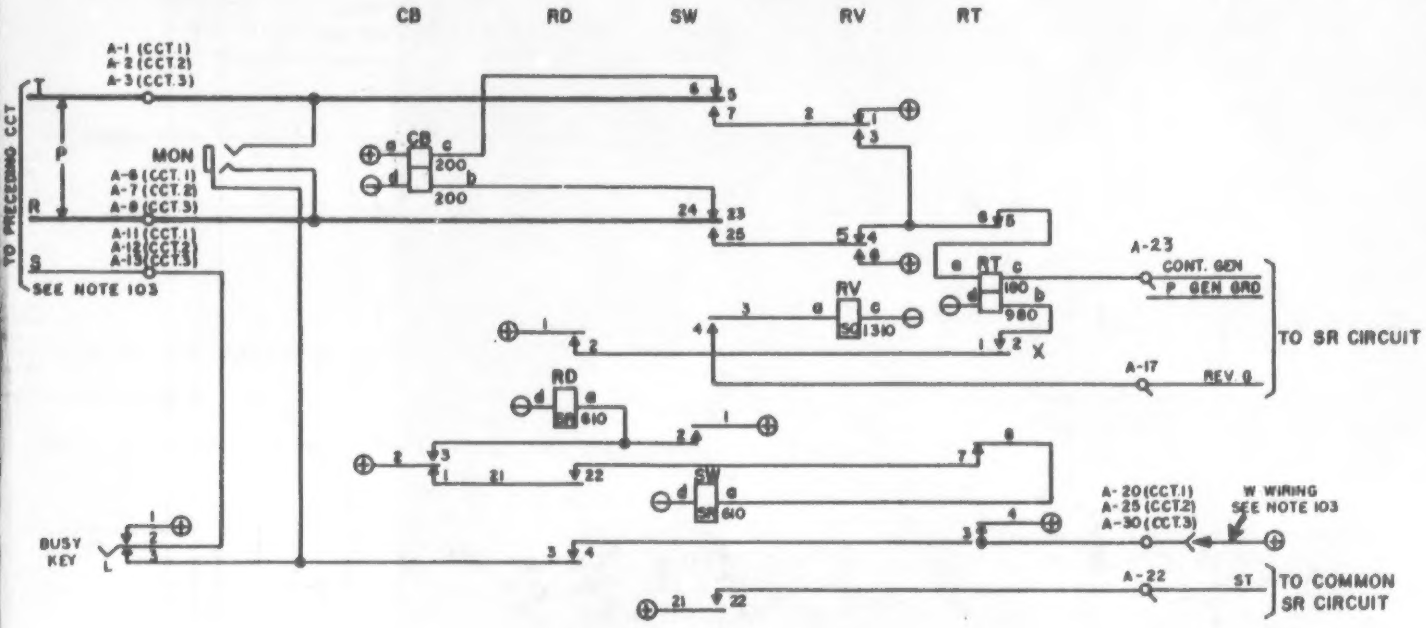
1 RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UF
2 X CONTACTS OPERATE FIRST
3 USE A WIRING TO PROVIDE SUPERVISION WHEN FIRE DEPARTMENT ANSWERS
4 USE B WIRING FOR AUTOMATIC EXTENSION OF ALL CALLS. B WIRING IS NORMALLY PROVIDED
5 USE C WIRING FOR OPERATOR EXTENSION OF ALL CALLS
6 USE D WIRING WHEN ALL CALLS ARE TO BE TRACED
7 USE E WIRING WHEN EXTENDED CALLS ARE TO BE TRACED
8 CIRCUIT 1 IS SHOWN WIRED. REFER TO TABLE FOR TERMINAL ASSIGNMENT OF OTHER CIRCUITS

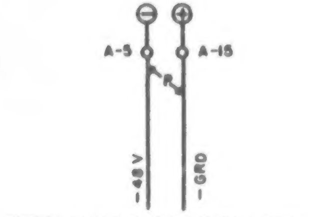
TABLE
TERMINAL ASSIGNMENTS

CIRCUIT NO	FA 1	FA 2
1	1	6
2	2	7
3	3	8

9 FIRE ALARM BELL CIRCUIT IS MOUNTED IN CABLE TURNING SECTION OF ATTENDANT'S SWITCHBOARD
10 FIRE ALARM RINGER CIRCUIT IS MOUNTED SEPARATELY
11 S LEAD IS WIRED THROUGH FRAME JACK DUST SWITCH. REMOVAL OF CIRCUIT PLATE CONNECTS THE S LEAD TO GROUND
12 ATTENDANT'S SWITCHBOARD CONTROLS ARE PROVIDED IN FIRST POSITIONAL UNIT ONLY

Foldout 9b. Schematic diagram of XY fire repeater circuit.





FUSING: 1 1/3 AMP PER 1,2 OR 3 CCTS.

INSPECTORS RINGBACK CIRCUIT

NOTES

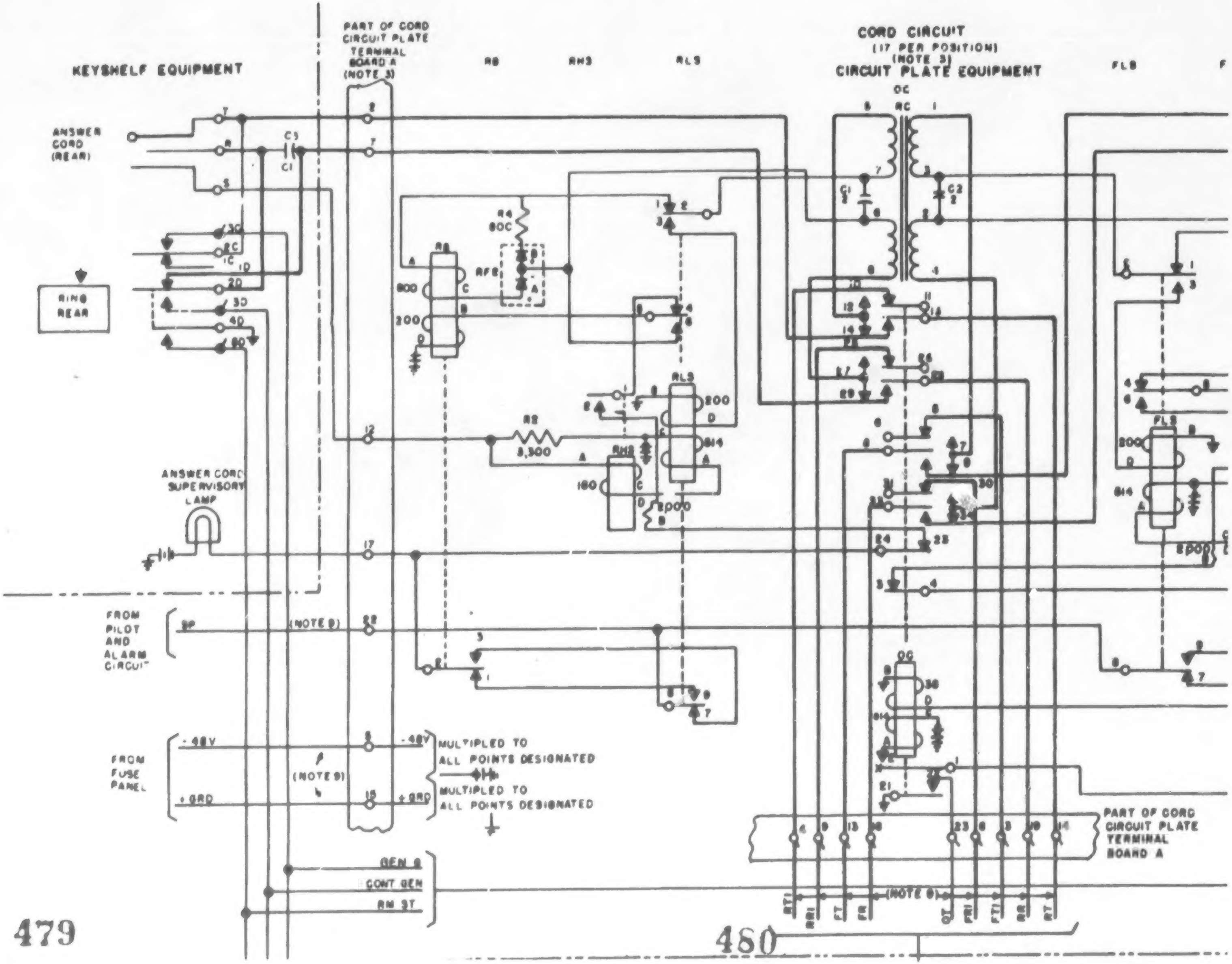
101– THE S LEAD IS WIRED THROUGH THE FRAME JACK BUSY SWITCH SO THAT REMOVAL OF THE CIRCUIT PLATE CONNECTS IT TO GROUND.

102– CONTACTS X OPERATE FIRST.

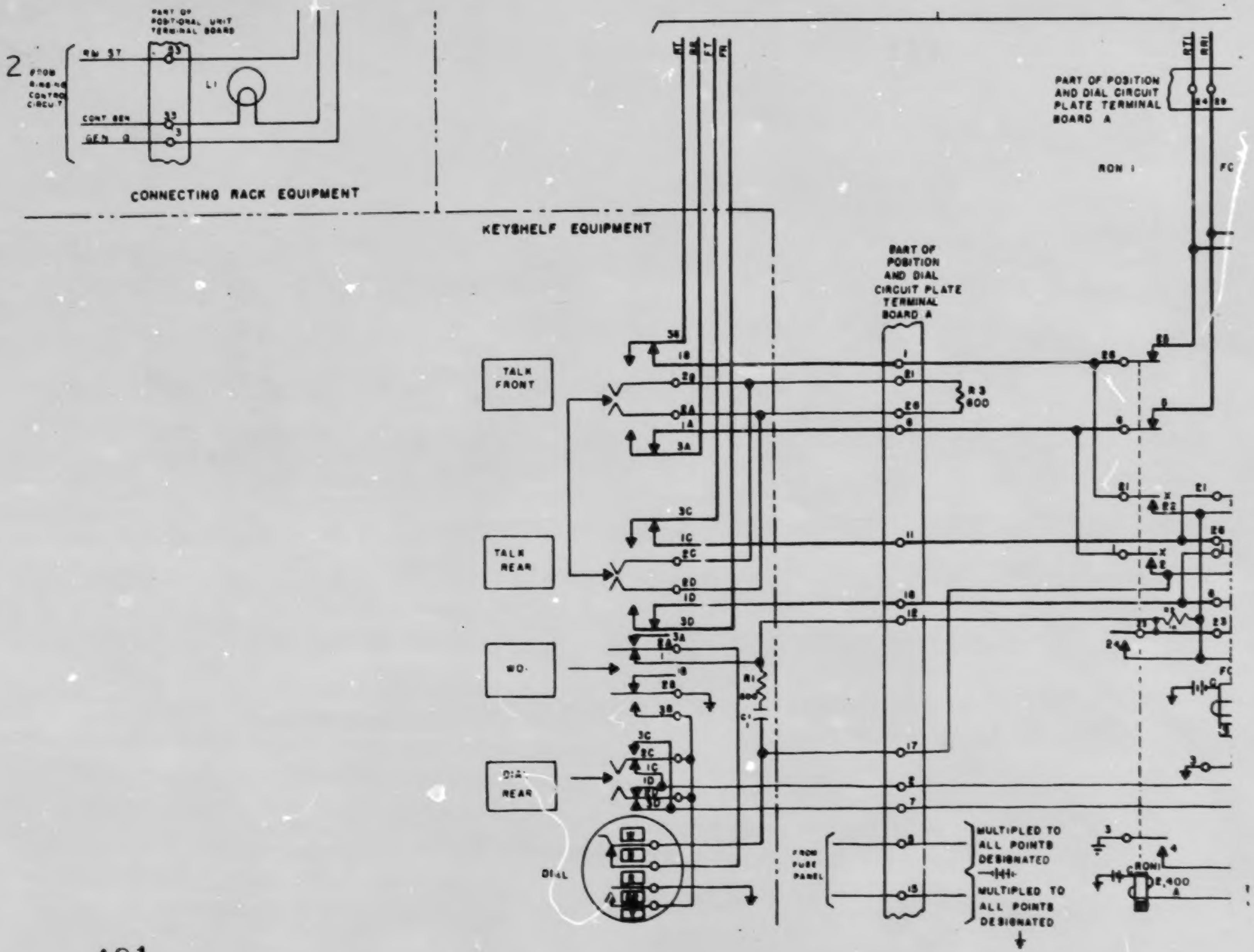
103– SPECIFY THE REMOVAL OF W WIRING IF THIS CIRCUIT IS TO RELEASE WHEN A CALL IS ANSWERED. UNLESS OTHERWISE SPECIFIED W WIRING SHALL BE PROVIDED TO HOLD CONNECTION WHEN CALL IS ANSWERED UNTIL DISCONNECT.

Foldout 11. Schematic diagram of XY inspector's ringback circuit.

LT 1


KEYSHELF EQUIPMENT
PART OF CORD CIRCUIT PLATE TERMINAL BOARD A (NOTE 3)
CORD CIRCUIT (17 PER POSITION) (NOTE 3)
CIRCUIT PLATE EQUIPMENT
RB
RHS
RLS
FLS
OC
RC
ANSWER CORD (REAR)
T
R
S
C3
C1
RING REAR
R4 80C
RFS
R2 3,300
RHS
RLS
FLS
OG
C1
C2
ANSWER CORD SUPERVISORY LAMP
FROM PILOT AND ALARM CIRCUIT
SP
(NOTE 9)
FROM FUSE PANEL
-48V
+GRD
(NOTE 9)
MULTIPLED TO ALL POINTS DESIGNATED
MULTIPLED TO ALL POINTS DESIGNATED
GEN 9
CONT GEN
RM ST
PART OF CORD CIRCUIT PLATE TERMINAL BOARD A
(NOTE 9)
RT1
RR1
FT
FR
OT
FR1
FT1
RR
RT

LT 2

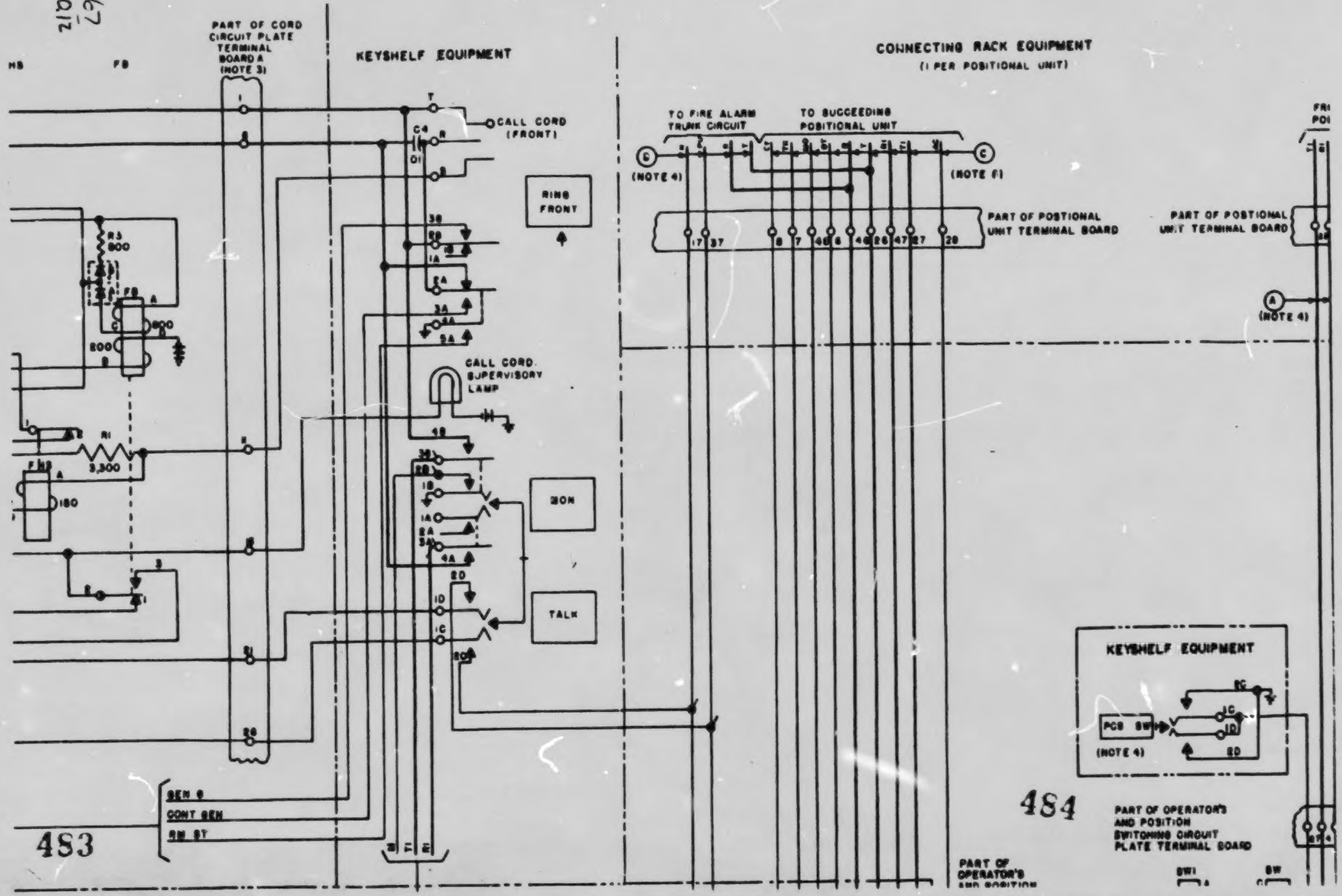


FROM RINGING CONTROL CIRCUIT
RM ST
CONT GEN
GEN G
PART OF POSITIONAL UNIT TERMINAL BOARD
33
3
L1
CONNECTING RACK EQUIPMENT
KEYSHELF EQUIPMENT
RT1
RR1
PART OF POSITION AND DIAL CIRCUIT PLATE TERMINAL BOARD A
RON 1
FC
PART OF POSITION AND DIAL CIRCUIT PLATE TERMINAL BOARD A
TALK FRONT
TALK REAR
MO.
DIAL REAR
DIAL
R3 600
R1 600
C1
FROM FUSE PANEL
MULTIPLED TO ALL POINTS DESIGNATED
MULTIPLED TO ALL POINTS DESIGNATED
RON1
2,400 A

466
Fo.12

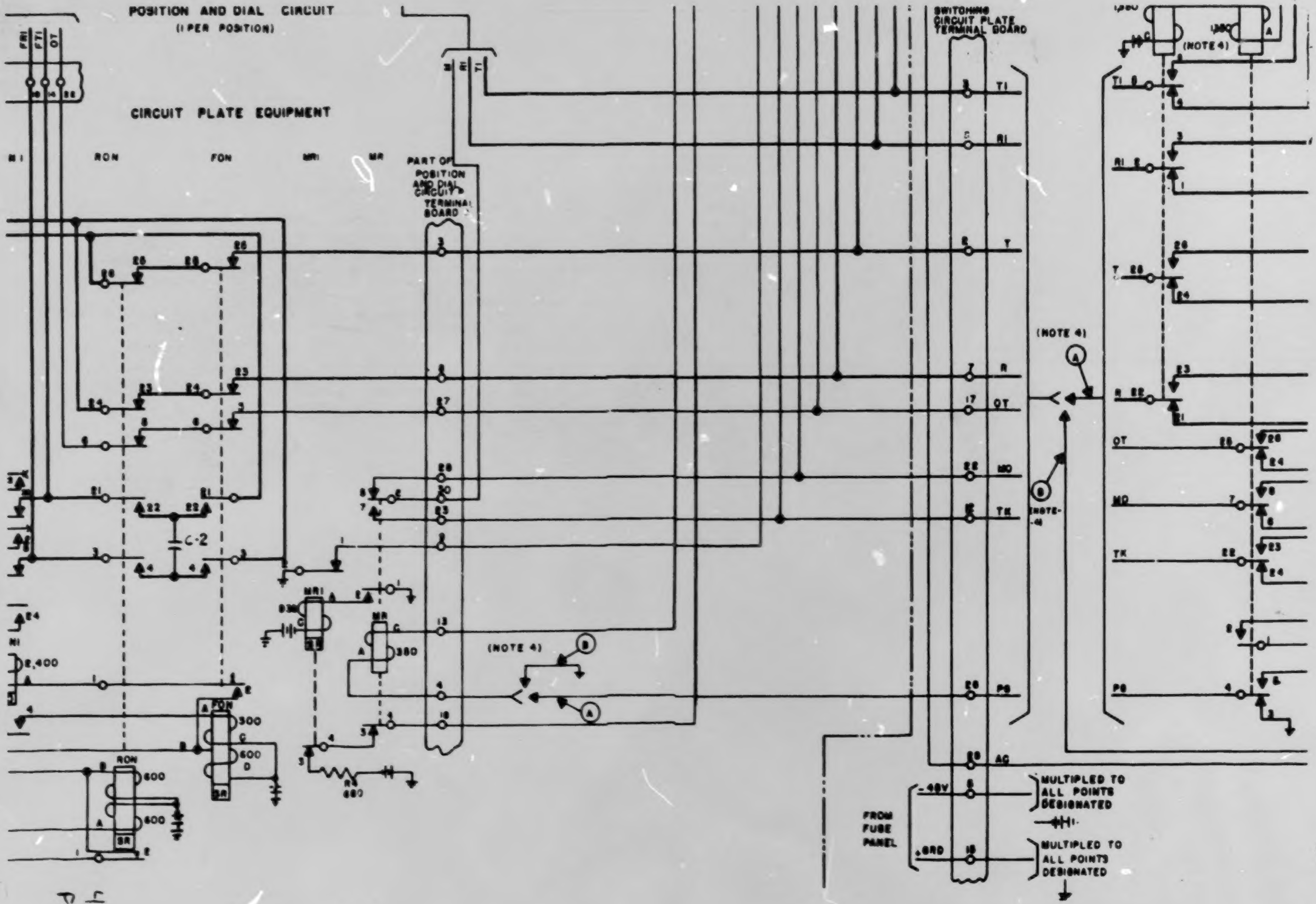
MD 1

467
FQ12


HS
FB
PART OF CORD CIRCUIT PLATE TERMINAL BOARD A (NOTE 3)
KEYSHELF EQUIPMENT
CONNECTING RACK EQUIPMENT
(I PER POSITIONAL UNIT)
T
CALL CORD (FRONT)
C4
.01
R
S
RING FRONT
R3 800
FB
A
800
200
CALL CORD SUPERVISORY LAMP
R1 3,300
180
MON
TALK
TO FIRE ALARM TRUNK CIRCUIT
TO SUCCEEDING POSITIONAL UNIT
(NOTE 4)
(NOTE F)
17
37
8
7
46
6
26
47
27
28
PART OF POSTIONAL UNIT TERMINAL BOARD
(NOTE 4)
KEYSHELF EQUIPMENT
PCS SW
(NOTE 4)
2C
1C
1D
2D
GEN G
CONT GEN
RN ST
PART OF OPERATOR'S AND POSITION
PART OF OPERATOR'S AND POSITION SWITCHING CIRCUIT PLATE TERMINAL BOARD
SW1
SW

483

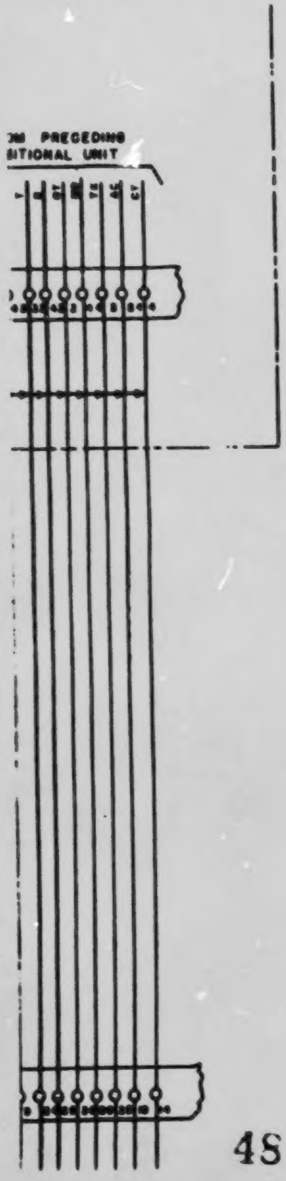
484


POSITION AND DIAL CIRCUIT
(1 PER POSITION)
CIRCUIT PLATE EQUIPMENT
FRI
FTI
OT
RI
RON
FON
MRI
MR
PART OF POSITION AND DIAL CIRCUIT TERMINAL BOARD
SWITCHING CIRCUIT PLATE TERMINAL BOARD
T1
R1
T
R
OT
MO
TK
PG
AC
C-2
2,400
300
600
380
R5
680
(NOTE 4)
A
B
-48V
+GRD
FROM FUSE PANEL
MULTIPLED TO ALL POINTS DESIGNATED
SR

RT 1

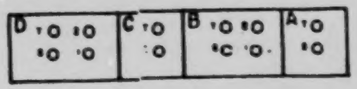
36251 04 S07 7603

Foldout 12



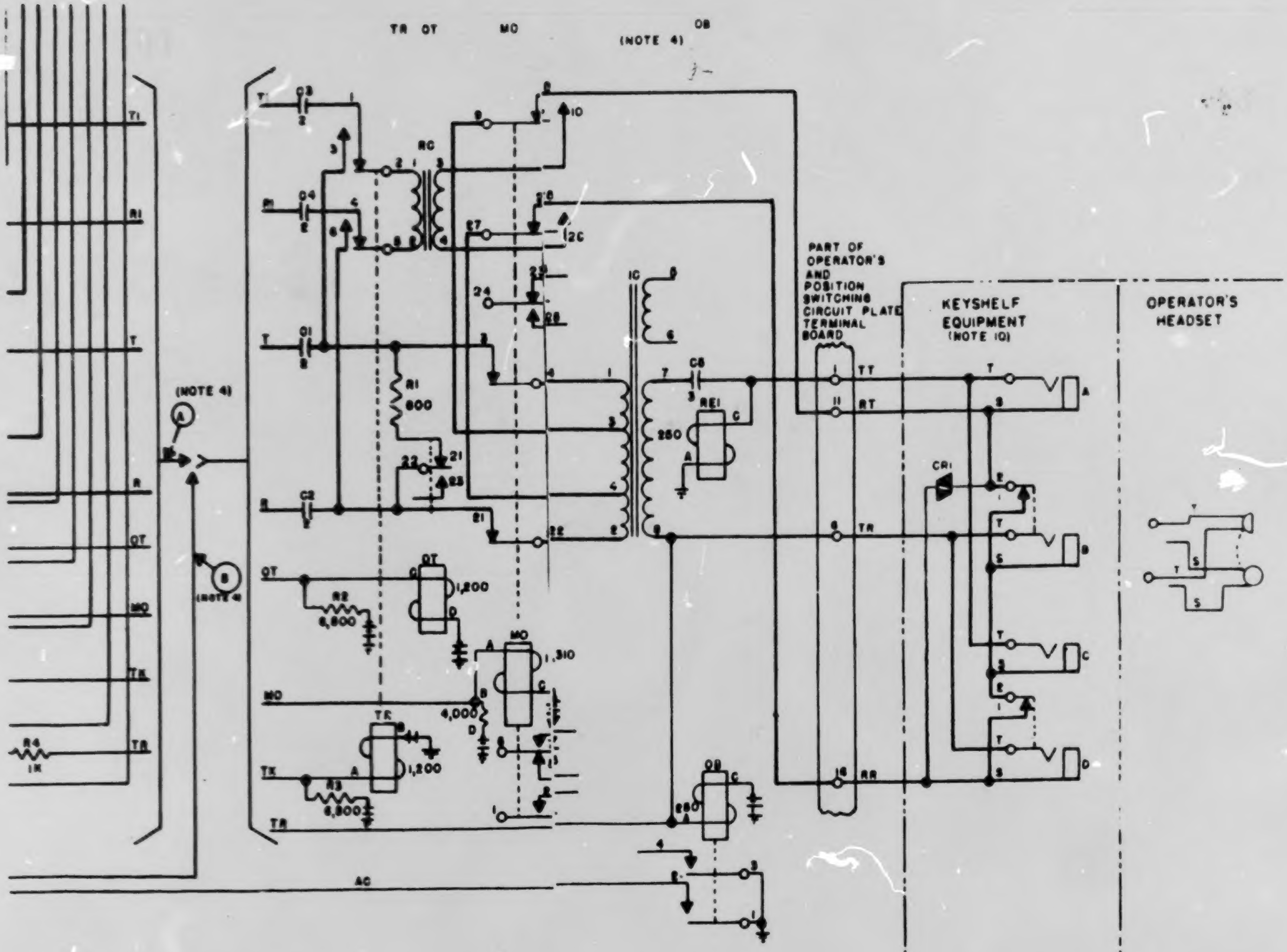
NOTES

1 RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UF
2 X CONTACTS OPERATE FIRST
3 TWO CORD CIRCUITS ARE MOUNTED ON EACH CORD CIRCUIT PLATE EXCEPT THE LAST ONE, CIRCUIT 1 (ODD NUMBERED) IS SHOWN WIRED, CIRCUIT 2 (EVEN NUMBERED) IS WIRED TO IDENTICAL TERMINAL OF TERMINAL BOARD C THE LAST CORD CIRCUIT (NO 17) IS WIRED TO TERMINAL BOARD A
4 A WIRING. POS SW SWITCH AND RELAYS SW AND SW1 (POSITION SWITCHING CIRCUIT) ARE PROVIDED IN ALL POSITIONAL UNITS EXCEPT THE FIRST. B WIRING IS USED IN THE FIRST POSITIONAL UNIT ONLY
5 C WIRING IS USED IN ALL POSITIONAL UNITS EXCEPT THE LAST
6 FIRE ALARM TRUNK CIRCUITS ARE PROVIDED ON THE FIRST POSITIONAL UNIT ONLY
7 ▭ DESIGNATES EQUIPMENT MARKING
8 WIRING TO TERMINALS 4,5,7,23 AND 25 NOT SHOWN THESE CONTACTS ARE USED ONLY WHEN SERVICE OBSERVING CIRCUIT IS SUPPLIED
9 THESE LEADS CONNECT TO TERMINAL BOARD A ONLY ARE MULTIPLED TO THE TWO CORD CIRCUITS ON THIS CIRCUIT PLATE AND TO THE SUCCEEDING CORD CIRCUIT PLATE
10 JACK TERMINAL ARE ARRANGED AS SHOWN BELOW

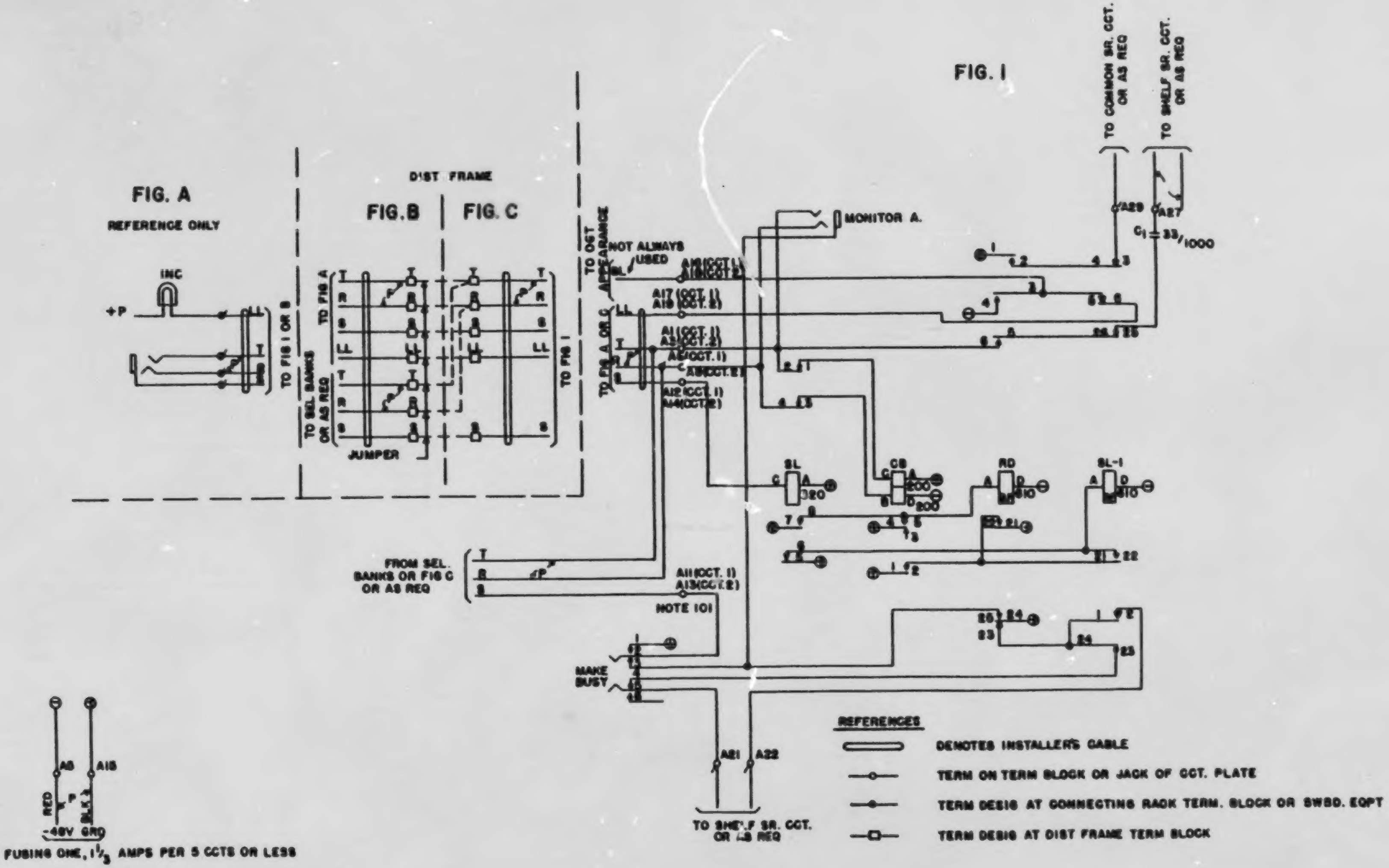


OPERATOR'S AND POSITION SWITCHING CIRCUIT
(1 PER POSITION)

CIRCUIT PLATE EQUIPMENT



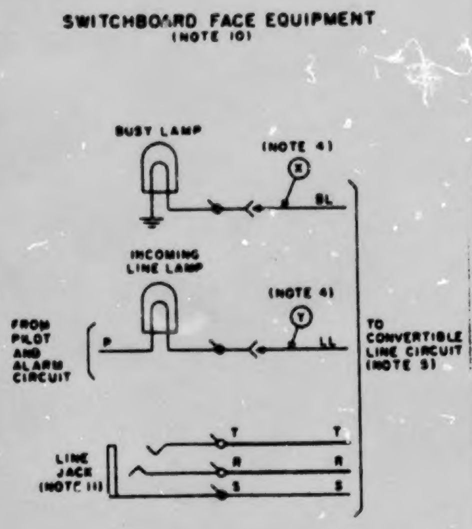
AU GAFS AL(784118)1M

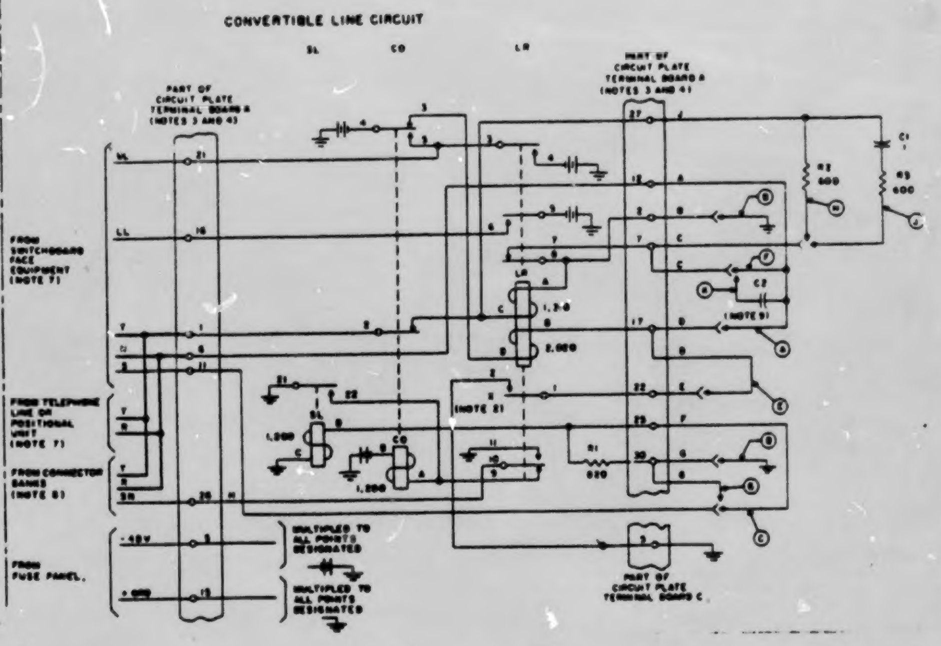


NOTES:

101-"S" LEAD WIRED THRU FRAME JACK BUSY SWITCH ON SHELF-TYPE EQUIPMENT SO THAT IT IS GROUNDED WHEN CCT. PLATE IS REMOVED.

Foldout 13. Schematic diagram of XY operator's/information trunk circuit.


SWITCHBOARD FACE EQUIPMENT
(NOTE 10)
BUSY LAMP
(NOTE 4)
X
BL
INCOMING LINE LAMP
(NOTE 4)
Y
FROM PILOT AND ALARM CIRCUIT
P
LL
TO CONVERTIBLE LINE CIRCUIT (NOTE 5)
LINE JACK (NOTE 11)
T
R
S


CONVERTIBLE LINE CIRCUIT
SL
CO
LR
PART OF CIRCUIT PLATE TERMINAL BOARD A (NOTES 3 AND 4)
FROM SWITCHBOARD FACE EQUIPMENT (NOTE 7)
BL
LL
T
R
S
FROM TELEPHONE LINE OR POSITIONAL UNIT (NOTE 7)
FROM CONNECTOR BANKS (NOTE 8)
SN
FROM FUSE PANEL.
-48V
+GRD
MULTIPLED TO ALL POINTS DESIGNATED
1,200
1,200
1,200
2,000
(NOTE 2)
(NOTE 9)
C1
C2
R1
R2
R3
PART OF CIRCUIT PLATE TERMINAL BOARD C

NOTES

1 RESISTANCES ARE IN OHMS, CAPACITANCES IN UF
2 X CONTACTS OPERATE FIRST
3 FOUR CIRCUITS ARE MOUNTED ON EACH CIRCUIT PLATE. CIRCUIT 1 IS SHOWN WIRED. REFER TO TABLE 1 FOR TERMINAL ASSIGNMENTS OF CIRCUITS 1 THROUGH 4 ON EACH CIRCUIT PLATE
4 TABLE 2 LISTS WIRING OPTIONS USED FOR EACH TYPE OF OPERATION
5 TWO-WAY INTERPOSITION TRUNKS REQUIRE TWO CONVERTIBLE LINE CIRCUITS AND TWO SWITCHBOARD FACE APPEARANCES. THE T AND R LEADS ARE REVERSED BETWEEN THE TWO JACKS
6 ONE WAY INTERPOSITION TRUNKS REQUIRE ONE CONVERTIBLE LINE CIRCUIT AND TWO SWITCHBOARD FACE APPEARANCES. THE T AND R LEADS ARE REVERSED BETWEEN THE TWO JACKS
7 CONNECTIONS BETWEEN THE CONVERTIBLE LINE CIRCUIT AND OTHER EQUIPMENT ARE MADE AT THE IDF OR CDF
8 THE T, R AND SN LEADS ARE CONNECTED TO THE CONNECTOR BANKS AT THE CDF WHEN CONNECTOR ACCESS IS USED FOR CB LINES
9 CAPACITOR C2 IS NOT SUPPLIED WITH THIS EQUIPMENT. ITS VALUE SHOULD BE BETWEEN .25 AND 1.0 UF
10 T, R, S, LL, AND BL LEADS OF SWITCHBOARD FACE APPEARANCES ARE NOT MULTIPLED WHEN USED FOR INTERPOSITION TRUNKS. THE S LEAD IS NOT USED AT THE OUTGOING JACK OF ONE-WAY INTERPOSITION TRUNKS.
11 JACK TERMINALS ARE ARRANGED AS SHOWN BELOW.

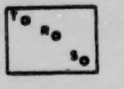


TABLE 1

TERMINAL ASSIGNMENTS FOR CIRCUIT PLATE TERMINAL BOARDS															
CKT NO	TERMINAL BOARD A TERMINAL NUMBERS AND LEADS														
	T	R	S	LL	BL	A	B	C	D	E	F	G	H	J	+ GRD	- 48 V
1	1	6	11	16	21	12	2	7	17	22	25	30	26	27	15 OF TERMINAL BOARD A AND 5 OF TERMINAL BOARD C	5 OF TERMINAL BOARD A
2	3	8	13	18	23	14	4	9	19	24	10	20	28	29		
CKT NO	TERMINAL BOARD C TERMINAL NUMBERS AND LEADS															
	T	R	S	LL	BL	A	B	C	D	E	F	G	H	J		
3	1	6	11	16	21	12	2	7	17	22	25	30	26	27		
4	3	8	13	18	23	14	4	9	19	24	10	20	28	29		

TABLE 2

FOR OPERATING WITH		USE WIRING OPTION											
		A	B	C	D	E	F	G	H	J	K	X	Y
COMMON BATTERY LINES		X	X	X	X							X	X
LOCAL BATTERY LINES						X	X	X				X	X
RING-DOWN TOLL LINES						X	X	X				X	X
CARRIER CIRCUITS	IF RINGING IS ADEQUATE								X				
	TO INCREASE RINGING SENSITIVITY									X			
ONE-WAY INCOMING DIAL TRUNK						X		X			X		X
ONE-WAY INTERPOSITION TRUNK		X	X	X	X								
	OUTGOING JACK											X	
	INCOMING JACK												X
TWO-WAY INTERPOSITION TRUNK		X		X	X							X	X

Foldout 14. Schematic diagram of XY convertible line circuit.

TOP 1

473
F.O.1

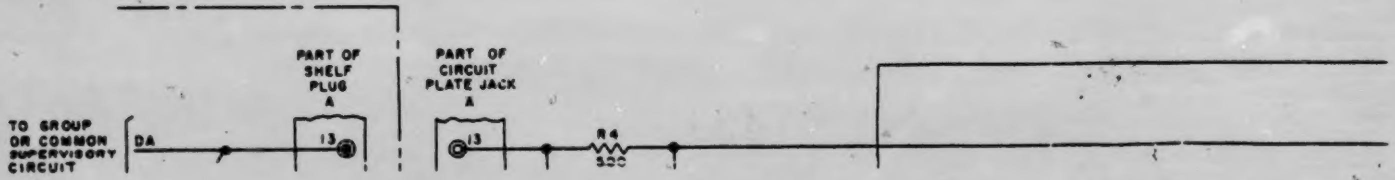
AU GAFS,AL(784133)1M

10

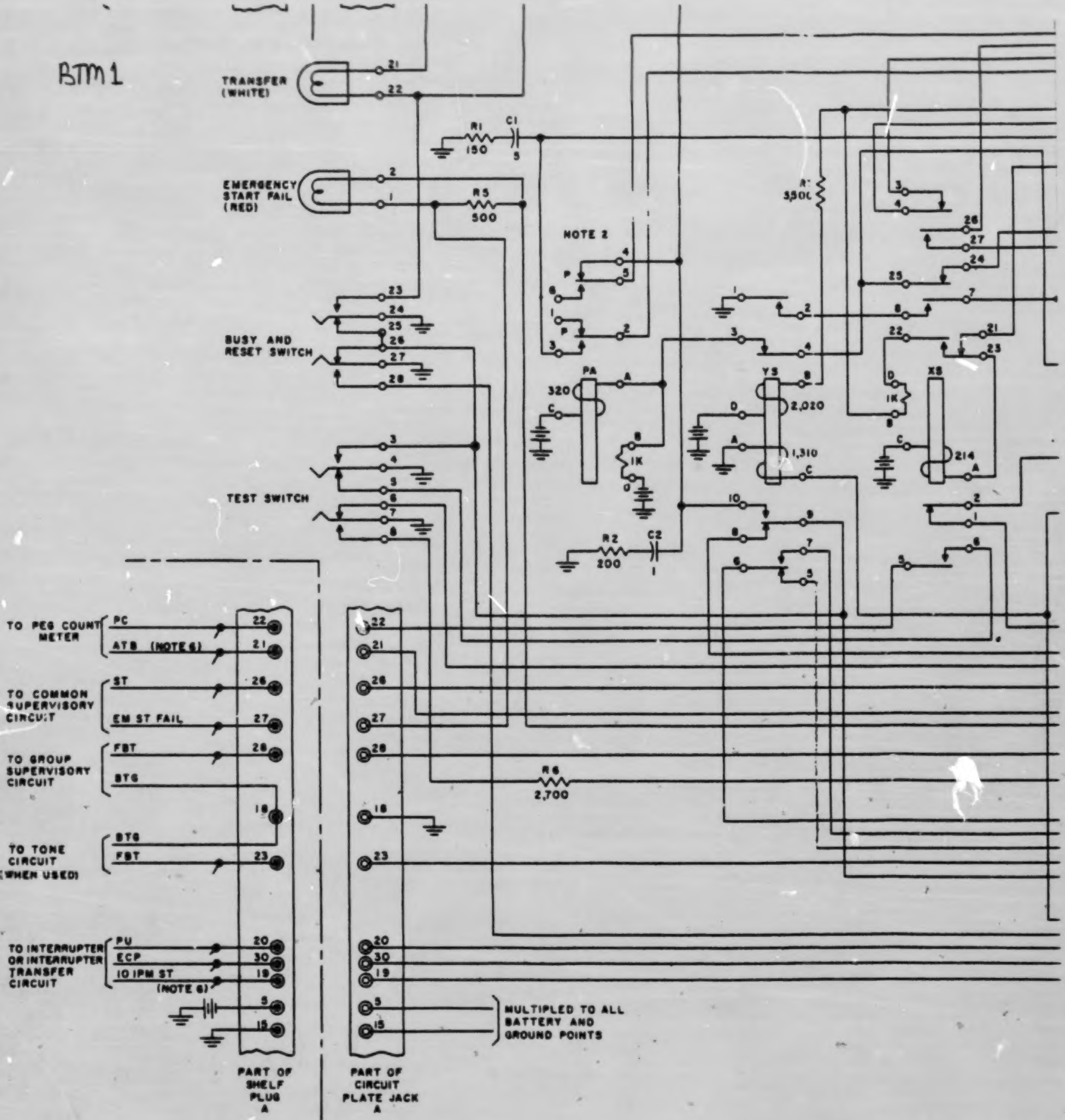
Foldout 1

NOTES

1. RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UF.
2. P CONTACTS ARE PULSING CONTACTS.
3. G LEAD IS WIRED THROUGH FRAME JACK BUSY SWITCH. REMOVAL OF CIRCUIT PLATE CONNECTS IT TO GROUND.
4. TFA AND TFB LEADS ARE WIRED THROUGH FRAME JACK BUSY SWITCHES. REMOVAL OF CIRCUIT PLATE CONNECTS THEM TO GROUND.
5. FBA AND FBB LEADS ARE WIRED THROUGH FRAME JACK BUSY SWITCHES. REMOVAL OF ASSOCIATED CIRCUIT PLATE CONNECTS FBA LEAD TO ATB LEAD OF SUPERVISORY CIRCUIT PLATE OR FBB LEAD TO 10 IPM LEAD.
6. 10 IPM AND ATB LEADS ARE USED ONLY WHEN ATB METERING IS USED. IF 6-SECOND-CYCLE INTERRUPTER IS USED, 10 IPM ST LEAD IS OMITTED AND 10 IPM LEAD IS STRAPPED TO ECP LEAD.
7. BANKS OF ROTARY SWITCHES A AND B ARE CONNECTED IN REVERSE MULTIPLE. WIRING OF ROTARY SWITCH BANKS SHOWN FOR ONE CIRCUIT ONLY.
8. ROTARY SWITCH LEVEL A IS NEAREST THE RATCHET.
9. STRAPS ARE OMITTED BETWEEN TERMINALS 2 THROUGH 6 ON ROTARY SWITCH B AND BETWEEN TERMINALS 14 THROUGH 19 ON ROTARY SWITCH A WHEN IT IS NECESSARY TO USE 18 LINEFINDERS IN ONE SHELF (PX AND PBX LINEFINDER SHELVES).

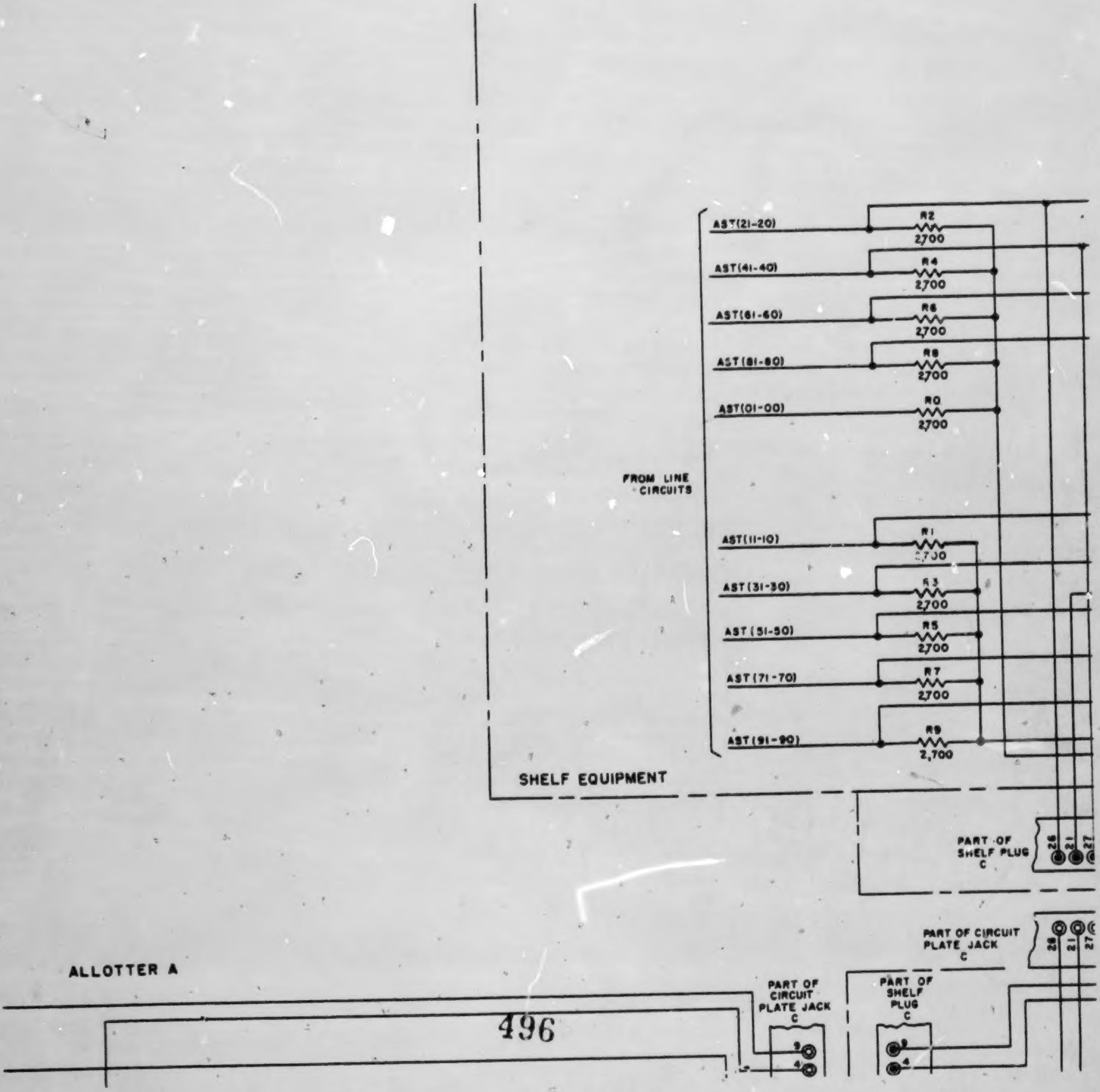

TO GROUP OR COMMON SUPERVISORY CIRCUIT
DA
PART OF SHELF PLUG A
13
PART OF CIRCUIT PLATE JACK A
13
R4
500

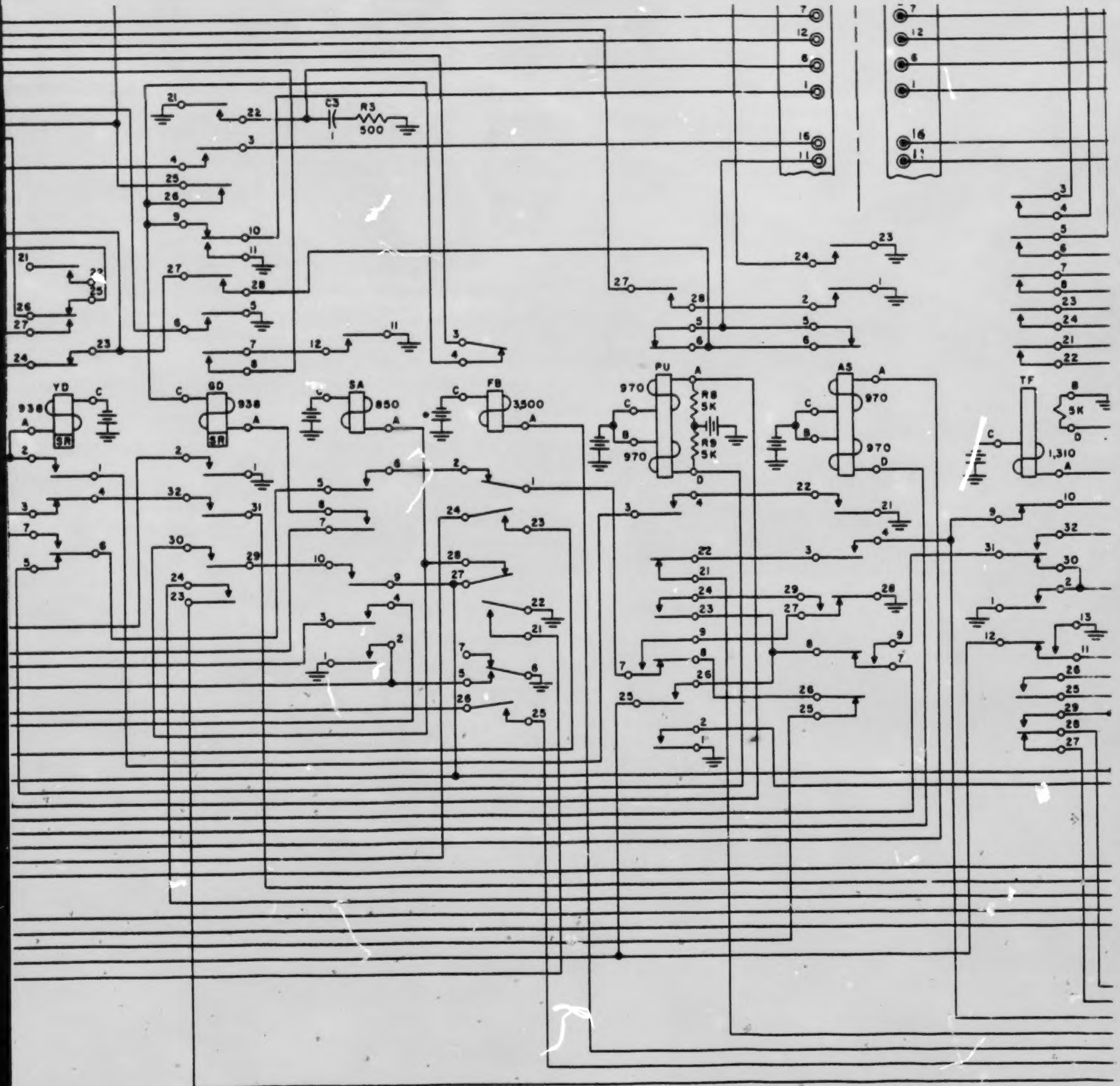
BTM 1



TRANSFER (WHITE)
EMERGENCY START FAIL (RED)
R1 150
C1 5
R5 500
R 3500
NOTE 2
BUSY AND RESET SWITCH
TEST SWITCH
PA 320
YS 2,020 1,310
XS 214
1K
R2 200
C2 1
R6 2,700
TO PEG COUNT METER
PC
ATB (NOTE 6)
TO COMMON SUPERVISORY CIRCUIT
ST
EM ST FAIL
TO GROUP SUPERVISORY CIRCUIT
FBT
BTG
TO TONE CIRCUIT (WHEN USED)
BTG
FBT
TO INTERRUPTER OR INTERRUPTER TRANSFER CIRCUIT
PU
ECP
10 IPM ST
(NOTE 6)
MULTIPLED TO ALL BATTERY AND GROUND POINTS
PART OF SHELF PLUG A
PART OF CIRCUIT PLATE JACK A

474
F.O.1


AST(21-20)
R2
2700
AST(41-40)
R4
2700
AST(61-60)
R6
2700
AST(81-80)
R8
2700
AST(01-00)
R0
2700
FROM LINE CIRCUITS
AST(11-10)
R1
2700
AST(31-30)
R3
2700
AST(51-50)
R5
2700
AST(71-70)
R7
2700
AST(91-90)
R9
2,700
SHELF EQUIPMENT
PART OF SHELF PLUG C
26
21
27
PART OF CIRCUIT PLATE JACK C
28
21
27
ALLOTTER A
PART OF CIRCUIT PLATE JACK C
9
4
PART OF SHELF PLUG C
9
4

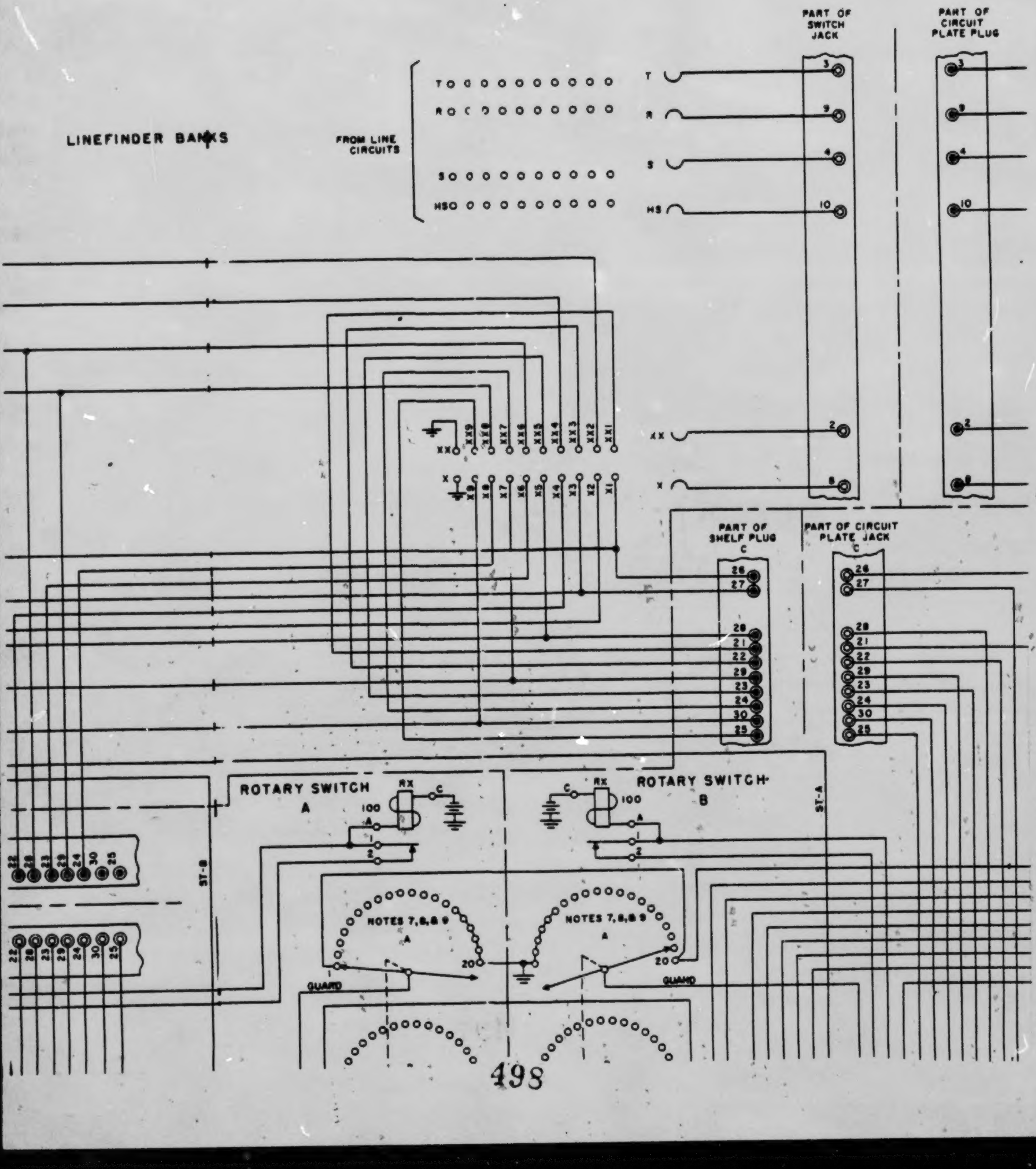


BTM 2

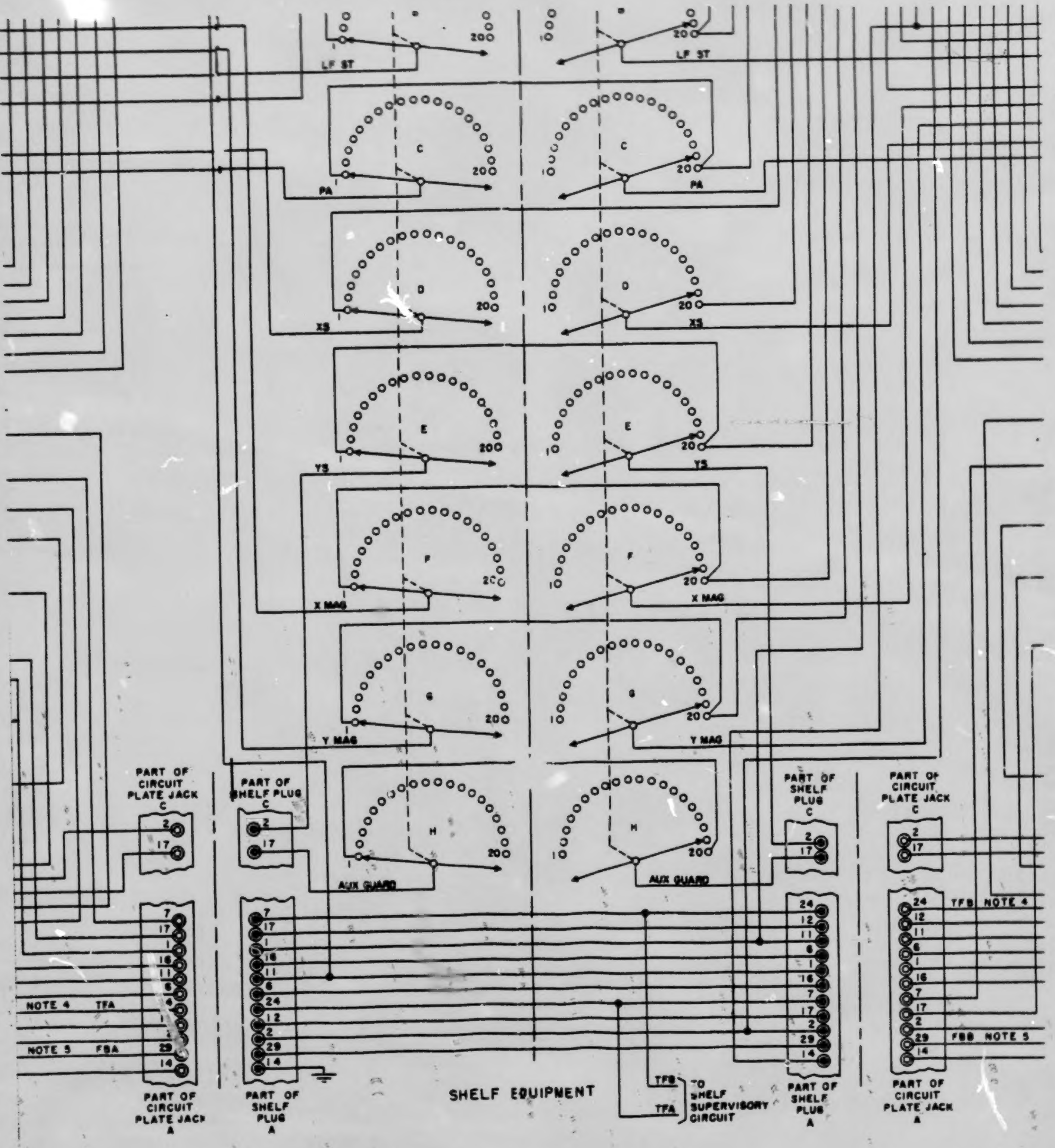
476
F.O.1

TOP 3

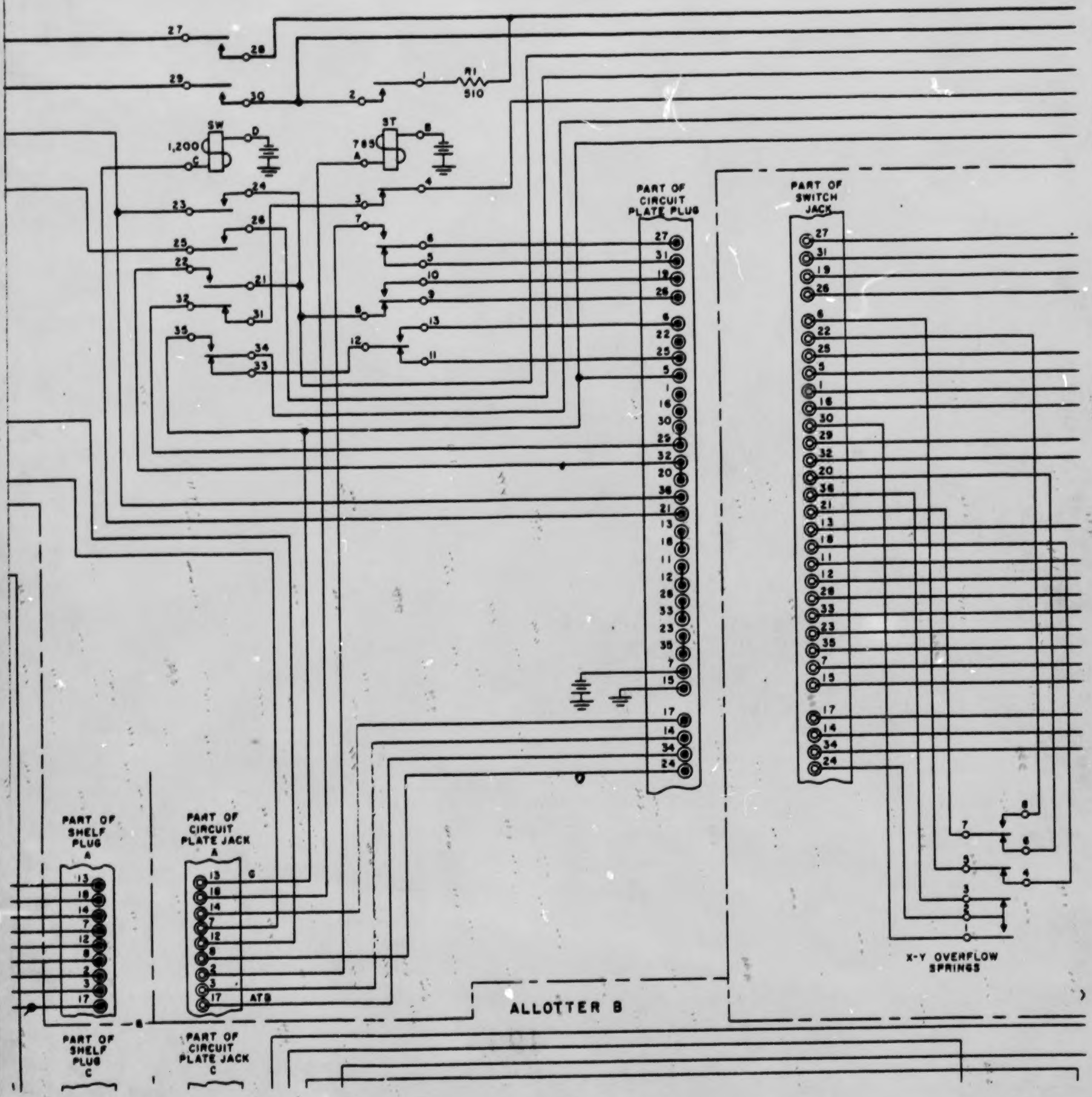
477
FO. 1

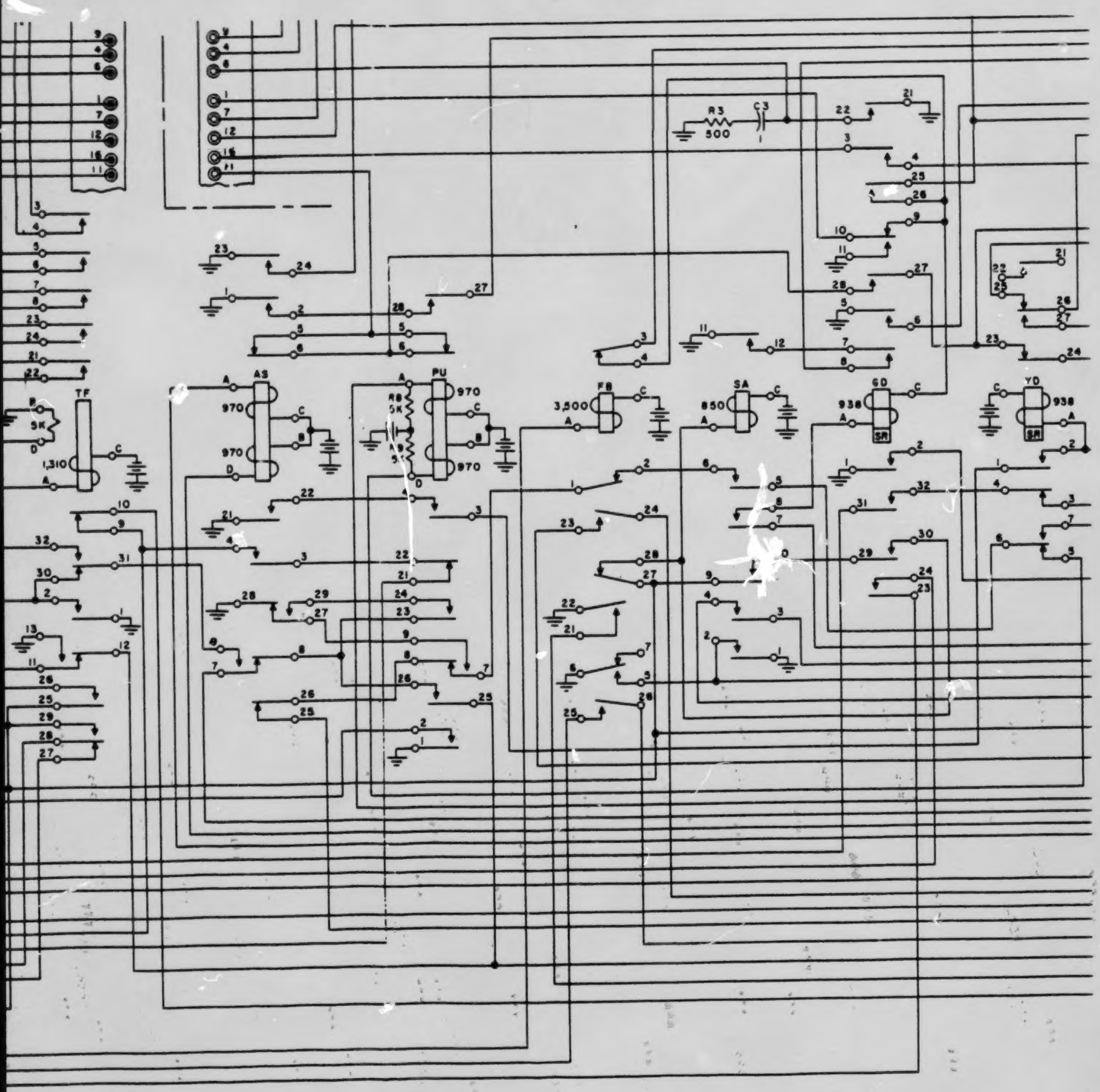


LINEFINDER BANKS
FROM LINE CIRCUITS
T
R
S
HSO
HS
PART OF SWITCH JACK
PART OF CIRCUIT PLATE PLUG
3
9
4
10
2
8
XX
X
XX1
XX2
XX3
XX4
XX5
XX6
XX7
XX8
XX9
X1
X2
X3
X4
X5
X6
X7
X8
X9
PART OF SHELF PLUG C
PART OF CIRCUIT PLATE JACK C
26
27
28
21
22
29
23
24
30
25
ROTARY SWITCH A
ROTARY SWITCH B
RX
C
100
A
1
2
NOTES 7, 8, & 9
20
GUARD
ST-A
ST-B


LF ST
PA
XS
YS
X MAG
Y MAG
AUX GUARD
C
D
E
F
G
H
1
20
PART OF CIRCUIT PLATE JACK C
PART OF SHELF PLUG C
PART OF CIRCUIT PLATE JACK A
PART OF SHELF PLUG A
NOTE 4
TFA
NOTE 5
FBA
TFB
FBB
TO SHELF SUPERVISORY CIRCUIT
SHELF EQUIPMENT

LINEFINDER CIRCUIT




R3
500
C3
1
TF
1,310
5K
AS
970
970
PU
970
970
R8
5K
FB
3,500
SA
850
GD
938
SR
YD
938
SR
A
B
C
D

BTM4

480
FO. 1

TOP 5

481
FO.1

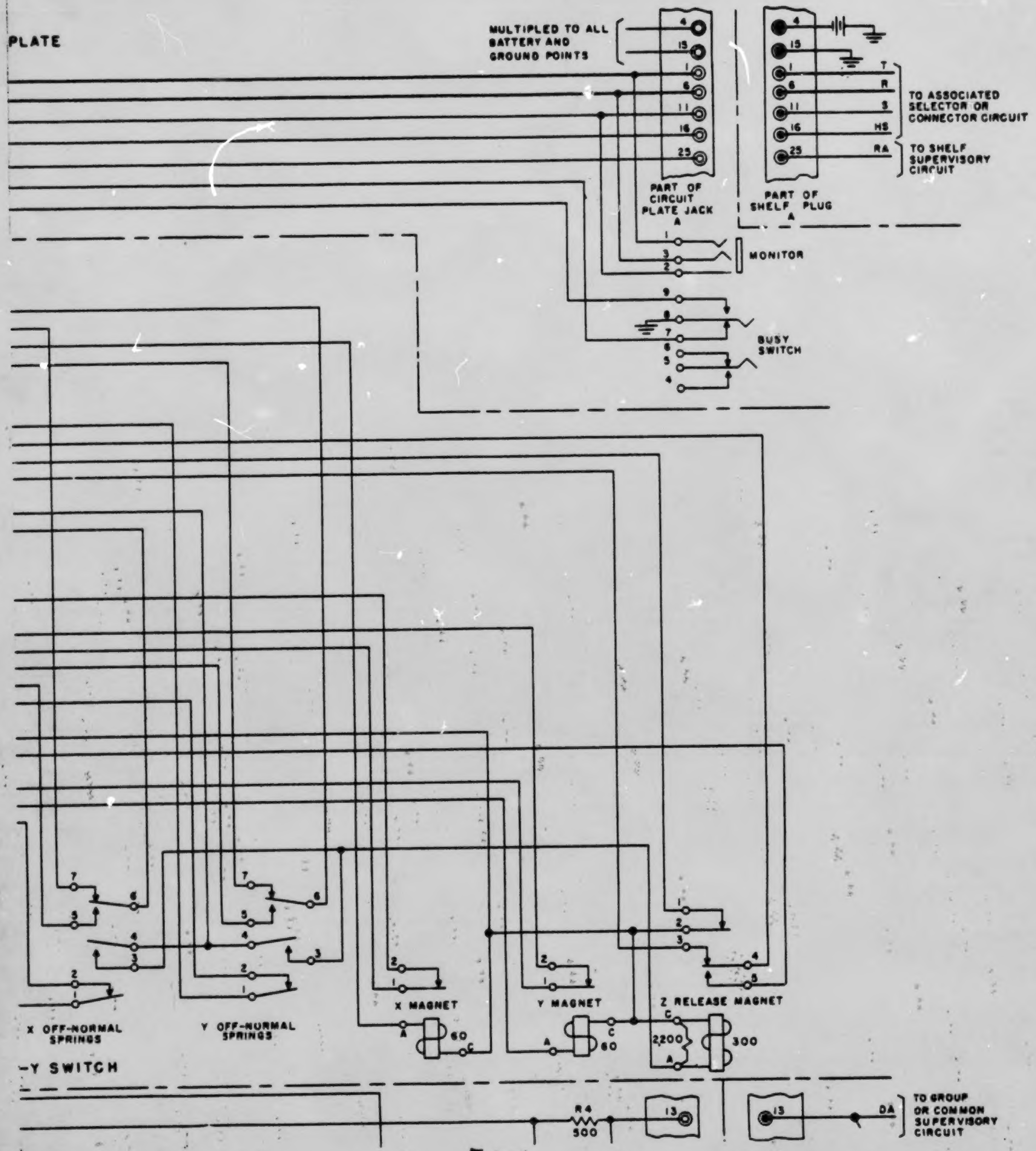
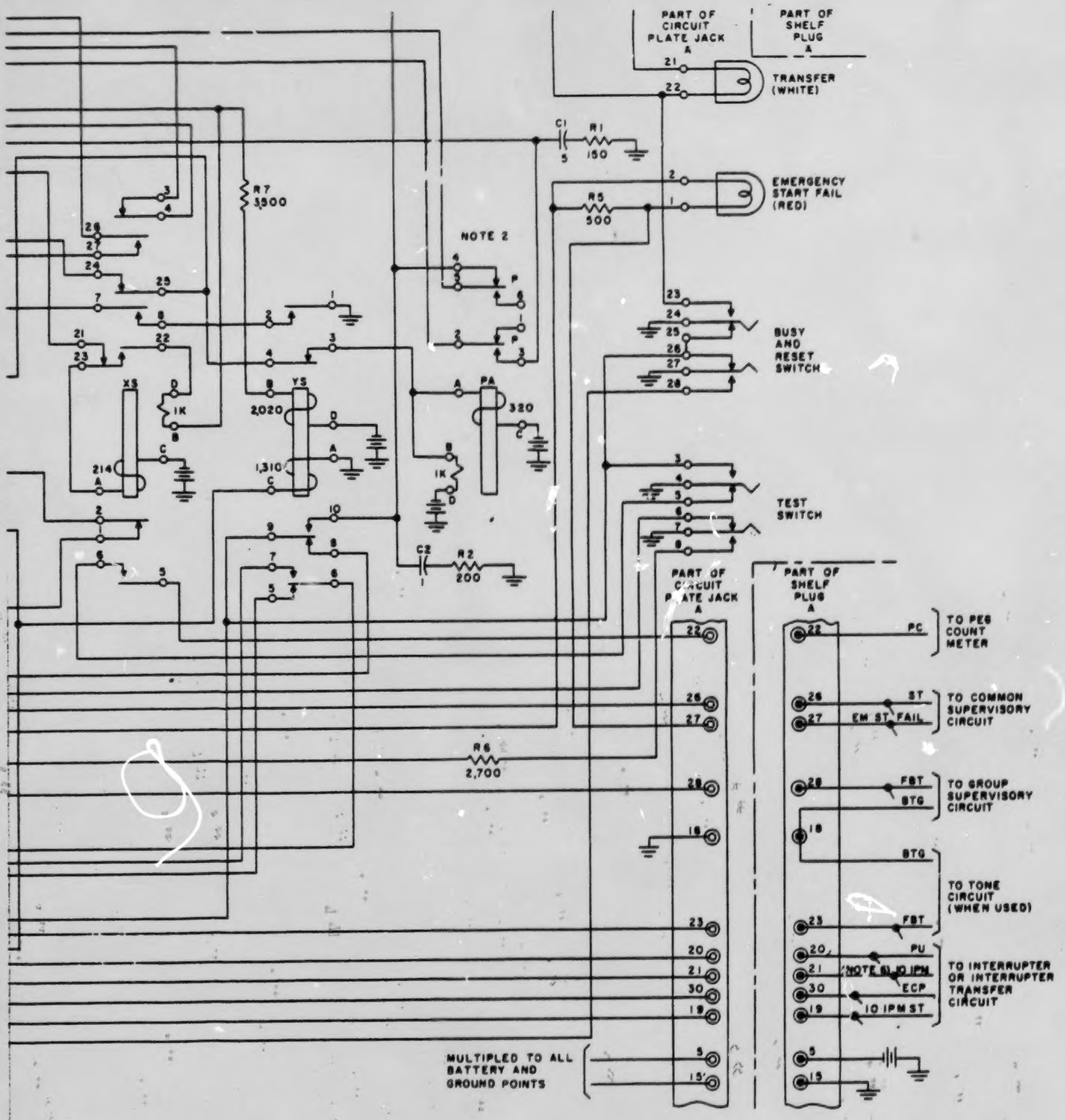


PLATE
MULTIPLED TO ALL BATTERY AND GROUND POINTS
4
15
1
6
11
16
25
T
R
S
HS
RA
TO ASSOCIATED SELECTOR OR CONNECTOR CIRCUIT
TO SHELF SUPERVISORY CIRCUIT
PART OF CIRCUIT PLATE JACK A
PART OF SHELF PLUG A
MONITOR
BUSY SWITCH
X OFF-NORMAL SPRINGS
Y OFF-NORMAL SPRINGS
X MAGNET
Y MAGNET
Z RELEASE MAGNET
60
60
2200
300
A
C
-Y SWITCH
R4
500
13
DA
TO GROUP OR COMMON SUPERVISORY CIRCUIT


PART OF CIRCUIT PLATE JACK A
PART OF SHELF PLUG A
TRANSFER (WHITE)
C1 5
R1 150
EMERGENCY START FAIL (RED)
R5 500
R7 3500
NOTE 2
BUSY AND RESET SWITCH
TEST SWITCH
XS
YS
PA
214
2,020
1,310
320
1K
C2 1
R2 200
R6 2,700
PART OF CIRCUIT PLATE JACK A
PART OF SHELF PLUG A
PC
TO PEG COUNT METER
ST
EM ST FAIL
TO COMMON SUPERVISORY CIRCUIT
FBT
BTG
TO GROUP SUPERVISORY CIRCUIT
BTG
TO TONE CIRCUIT (WHEN USED)
FBT
PU
(NOTE 6) 10 IPM
ECP
10 IPM ST
TO INTERRUPTER OR INTERRUPTER TRANSFER CIRCUIT
MULTIPLED TO ALL BATTERY AND GROUND POINTS
9
4

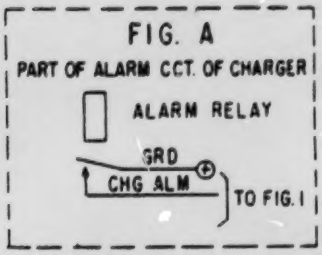
BTM 5
FO. 1

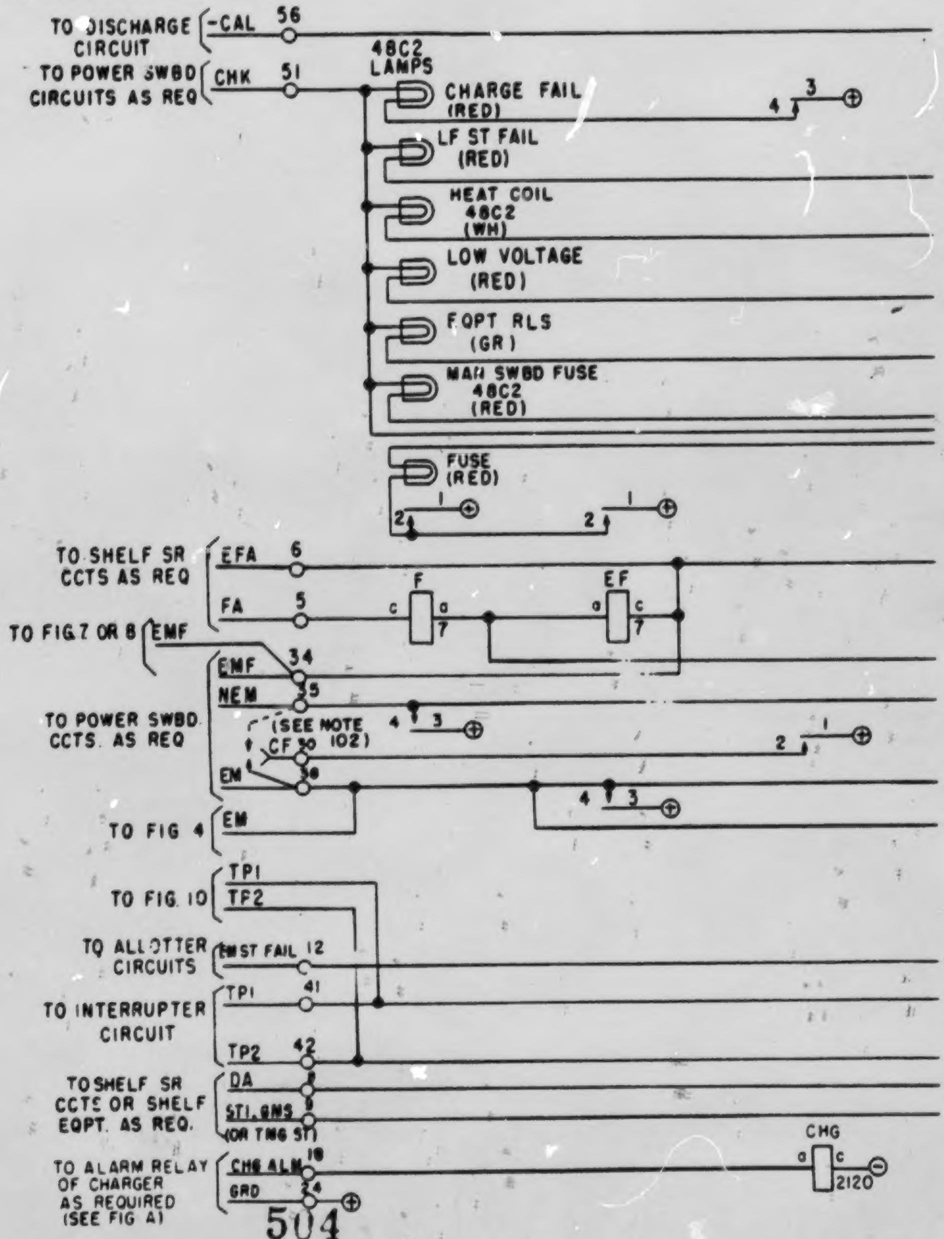
482

TP 1

:483
FO. 4

FIG. A





BTM 1

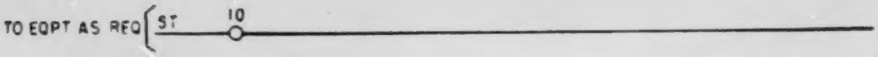


FIG. 3
MONITOR LAMP CONTROL SWITCH (SEE NOTE 103 & 104)

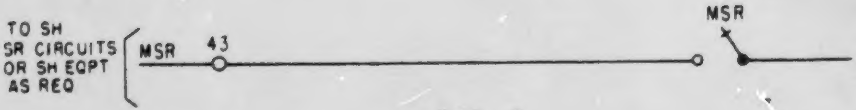
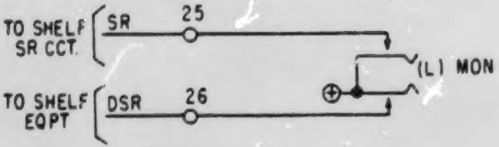


FIG. 5
MONITOR LAMP CONTROL
(SEE NOTE 103 & 104)

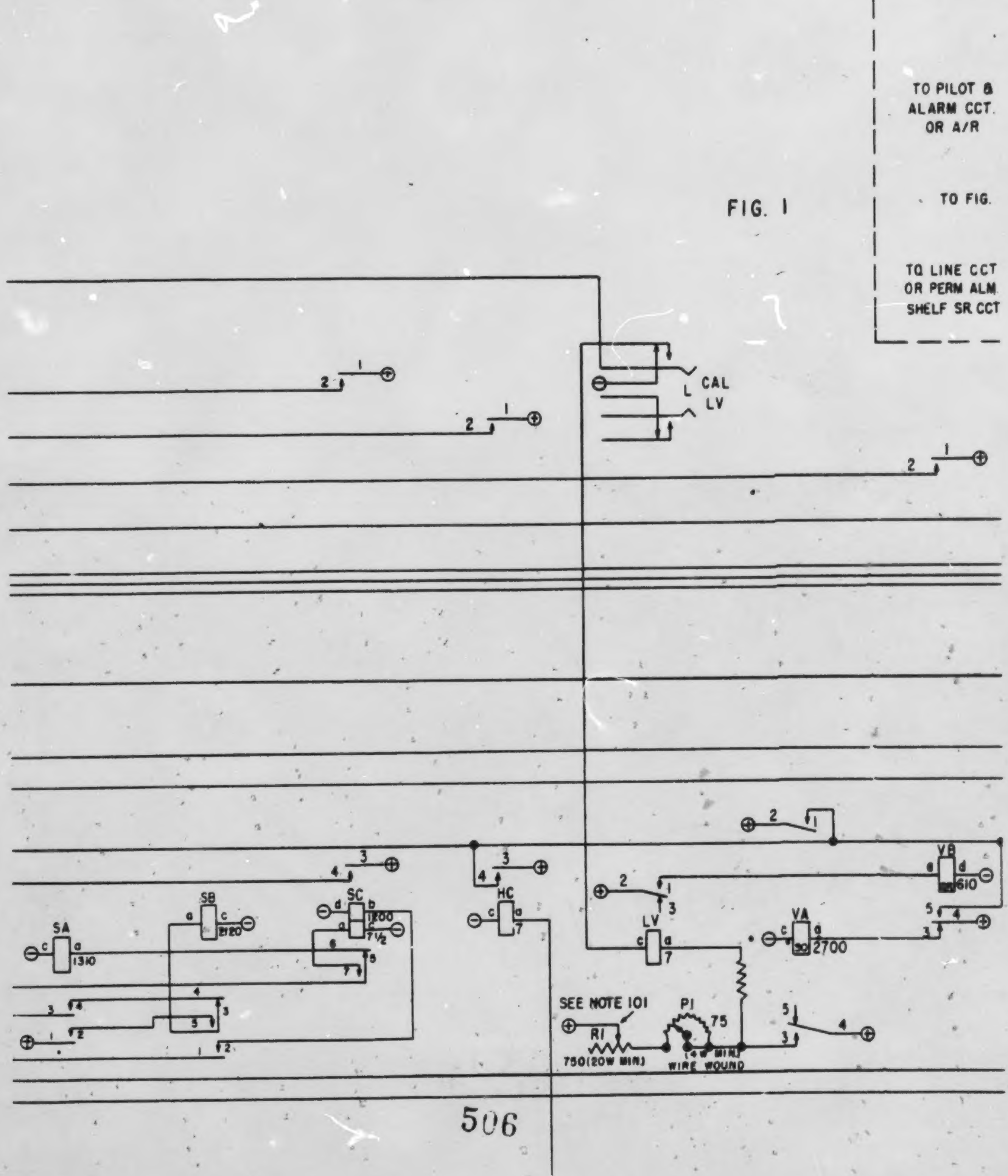


484
FO.4

TP 2

485
FO.4

FIG. 1



506

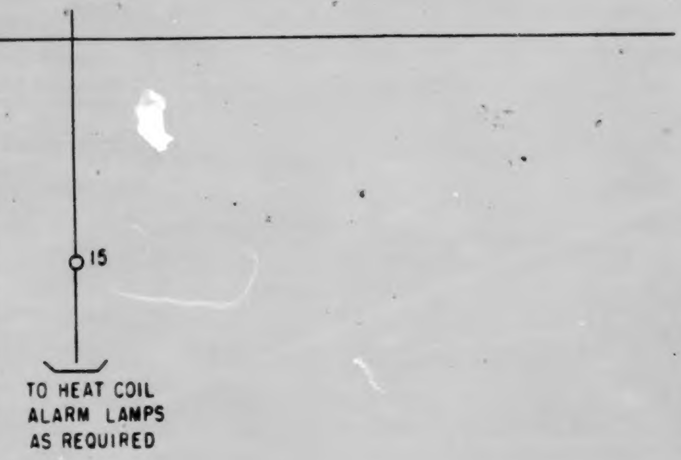


FIG. 7

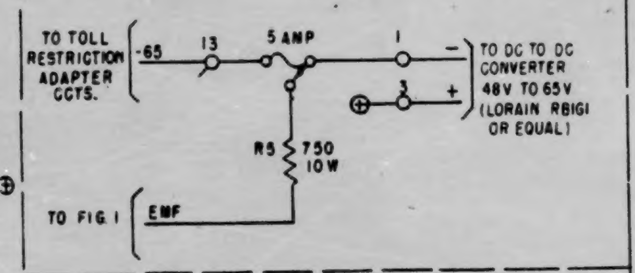
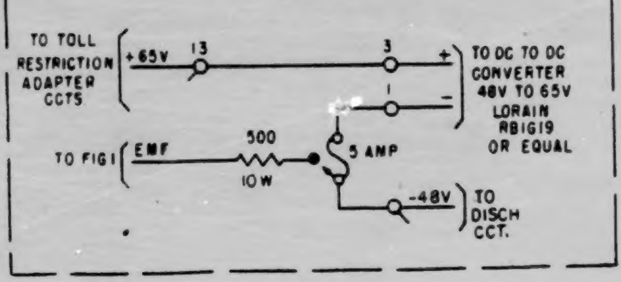

TO TOLL RESTRICTION ADAPTER CCTS.
-65
13
5 AMP
1
-
3
+
TO DC TO DC CONVERTER 48V TO 65V (LORAIN RBIGI OR EQUAL)
R5
750
10W
TO FIG 1
EMF

FIG. 8


TO TOLL RESTRICTION ADAPTER CCTS
+65V
13
3
+
1
-
TO DC TO DC CONVERTER 48V TO 65V LORAIN RBIGI9 OR EQUAL
TO FIG1
EMF
500
10W
5 AMP
-48V
TO DISCH CCT.

BTM2

486
FO.4

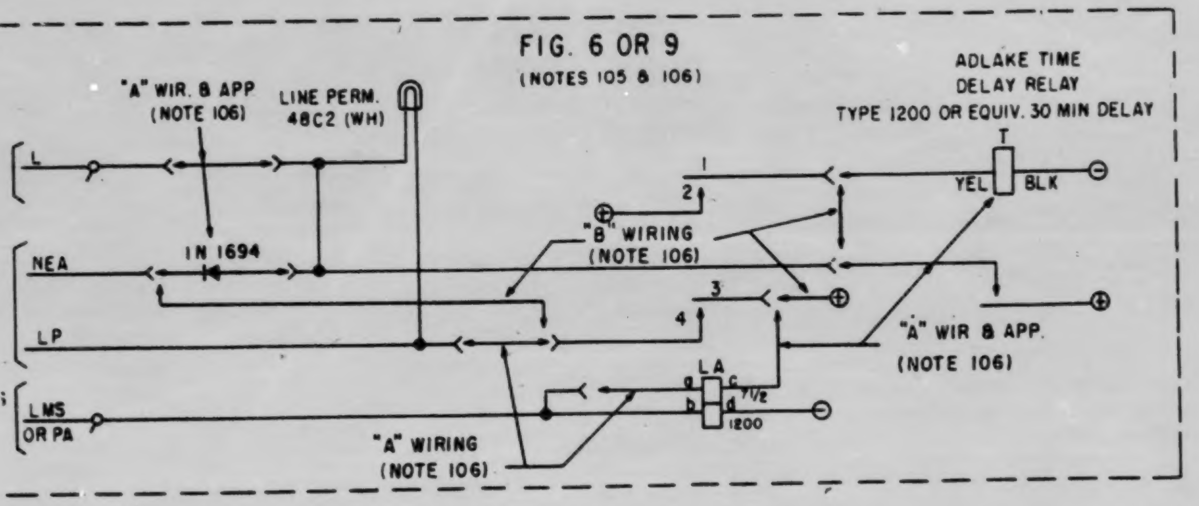
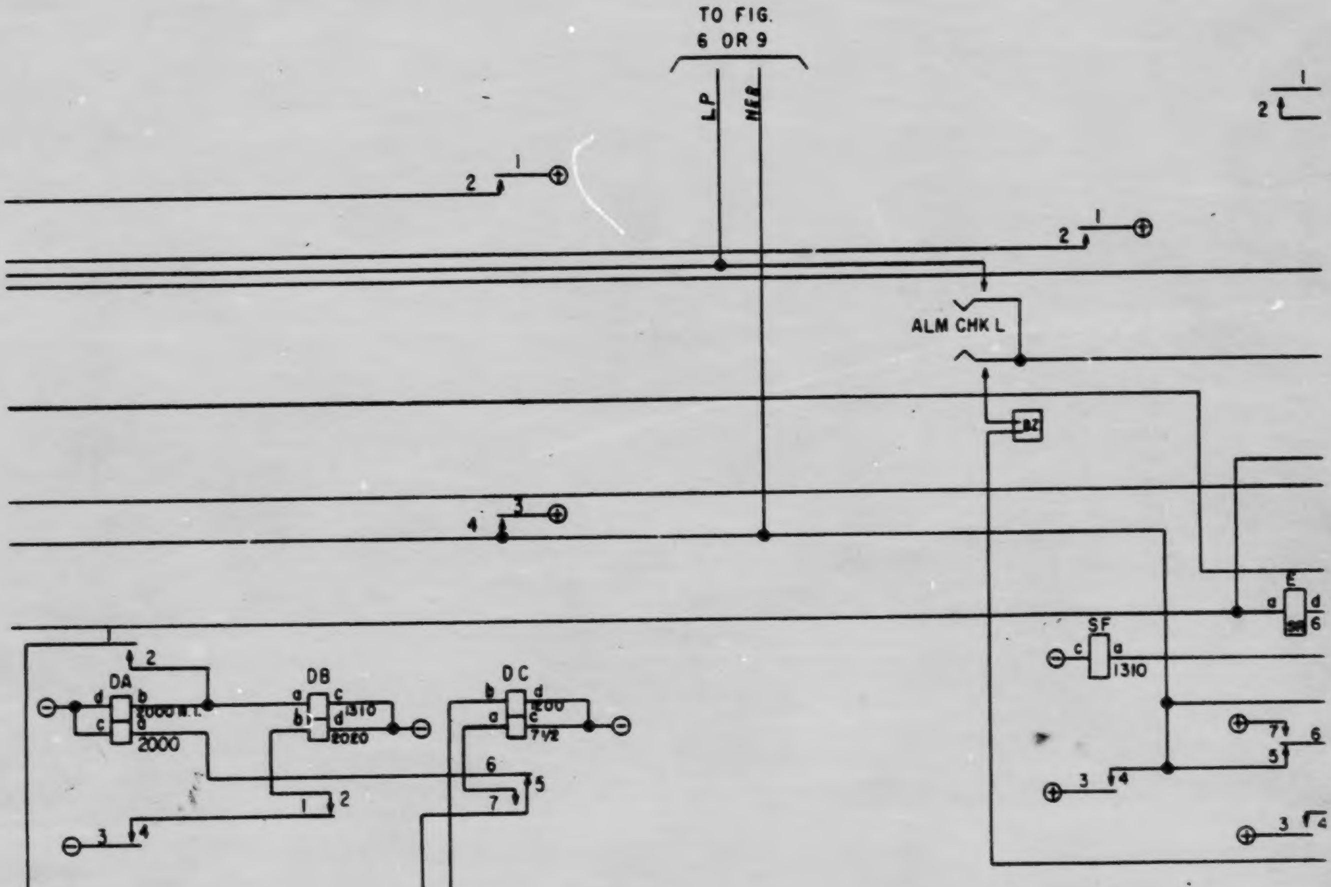
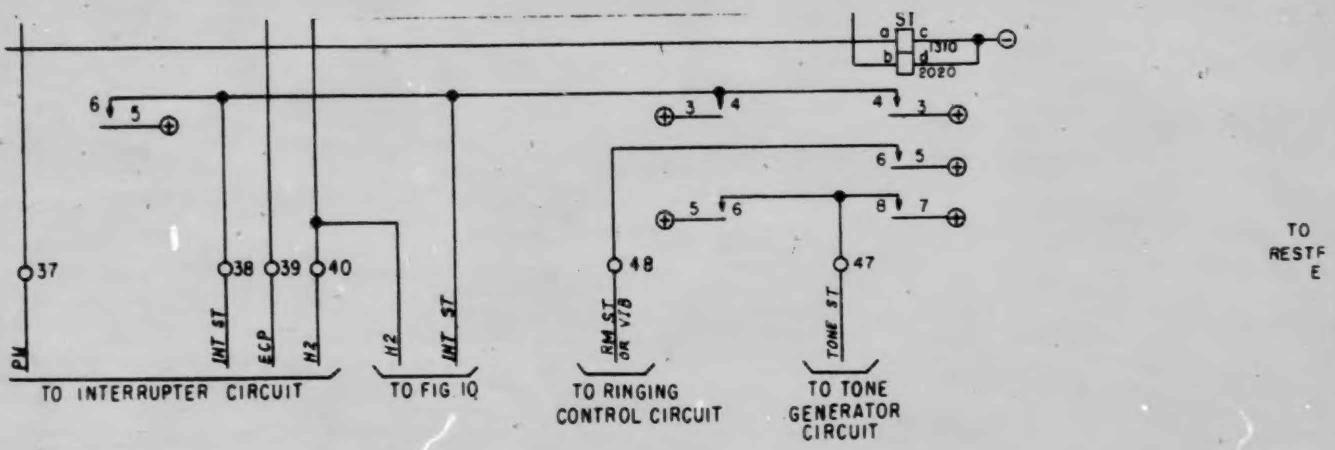


FIG. 6 OR 9
(NOTES 105 & 106)
"A" WIR. & APP
(NOTE 106)
LINE PERM.
48C2 (WH)
ADLAKE TIME
DELAY RELAY
TYPE 1200 OR EQUIV. 30 MIN DELAY
T
YEL
BLK
L
NEA
IN 1694
LP
LMS
OR PA
"B" WIRING
(NOTE 106)
"A" WIR & APP.
(NOTE 106)
LA
71/2
1200
"A" WIRING
(NOTE 106)
1
2
3
4
a
b
c
d


TO FIG.
6 OR 9
LP
NEA
ALM CHK L
BZ
E
SF
1310
DA
2000 W.L.
2000
DB
1310
2020
DC
200
71/2
STI
1310
2020
a
b
c
d
1
2
3
4
5
6
7


ST
a
b
c
d
1310
2020
6
5
3
4
4
3
6
5
5
6
8
7
37
38
39
40
48
47
PM
INT ST
ECP
H2
H2
INT ST
RM ST OR VIB
TONE ST
TO INTERRUPTER CIRCUIT
TO FIG 1Q
TO RINGING CONTROL CIRCUIT
TO TONE GENERATOR CIRCUIT
TO
RESTF
E

BTM 3

488
FO. 4

TP 4

489

FO. 4

NOTES:

101 RESISTORS R1 & P1 SHALL BE ADJUSTED TO RELEASE RELAY LV ON 45 1/2 VOLTS WITH CONTACTS 3 & 4 OF RELAY VA OPEN.

102 UNLESS OTHERWISE SPECIFIED, TERMINAL CF IS NORMALLY STRAPPED TO EM TERMINAL FOR EMERGENCY ALARM SIGNAL FOR CHARGER FAILURE.

103 SPECIFY FIG. 3 WHEN WHEN ROW SUPERVISORY EQUIPMENT IS NOT PROVIDED.

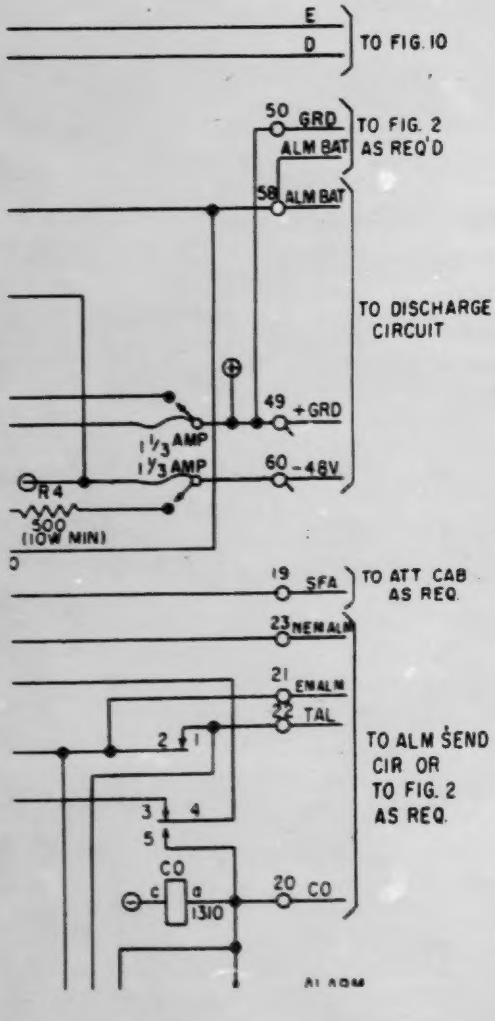
104. SPECIFY FIG. 5 INSTEAD OF FIG 3 WHEN MONITOR LAMPS AT EQUIPMENT ARE GROUND CONNECTED.

105. SPECIFY FIG. 6 WHEN 30 MINUTE DELAYED ALARM ASSOCIATED WITH A LINE CCT PERMANENT CONDITION IS REQUIRED.

106. PRIOR TO ISSUE 10 "A" WIRING & APPARATUS WERE PART OF FIG. 6 & "B" WIRING & FIG. 9 WERE NOT SHOWN. WITH ISSUE 10 "A" WIRING & APPARATUS REMAIN PART OF FIG. 6 & "B" WIRING BECOMES PART OF FIG 9. SPECIFY FIG. 9 FOR USE IN AN OFFICE WITH 100% NON-LOCKOUT LINES.

107. SPECIFY FIG 10 WITH "C" WIRING, IF 4-6 MIN. AUTOMATIC AUDIBLE ALARM CUTOFF UNDER CONTROL OF DAY BATTERY KEY IS REQUIRED. OMIT "C" WIRING IF 4-6 MIN. AUTO. AUD. ALARM CUTOFF IS TO BE EFFECTIVE ALL THE TIME.

FIG. 10
(NOTE 107)
4-6 MIN AUTOMATIC AUDIBLE ALARM CUT OFF



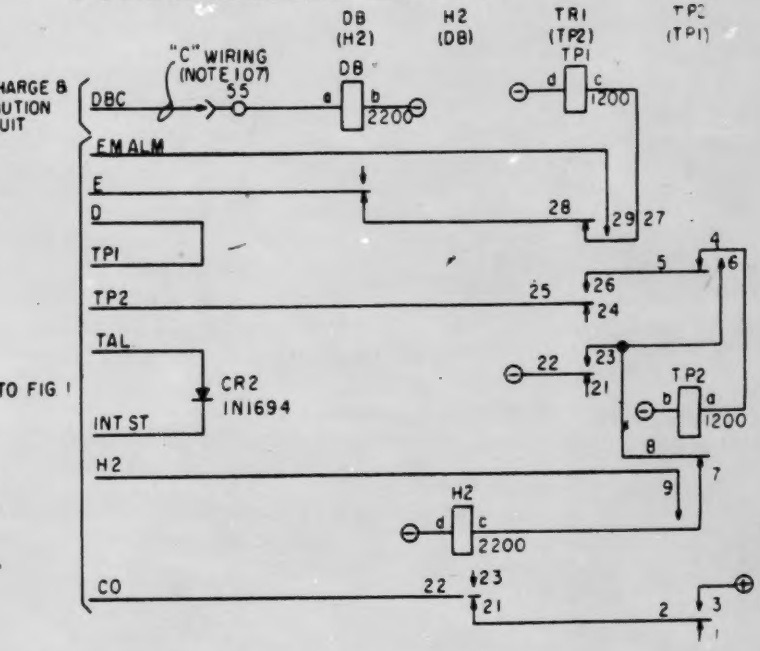
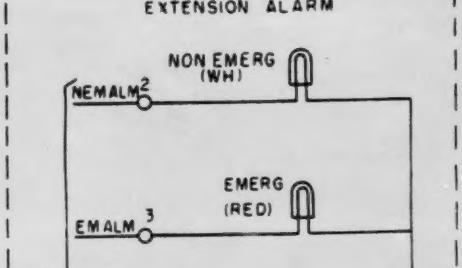


FIG. 2
EXTENSION ALARM



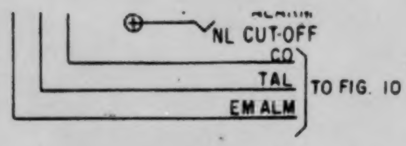
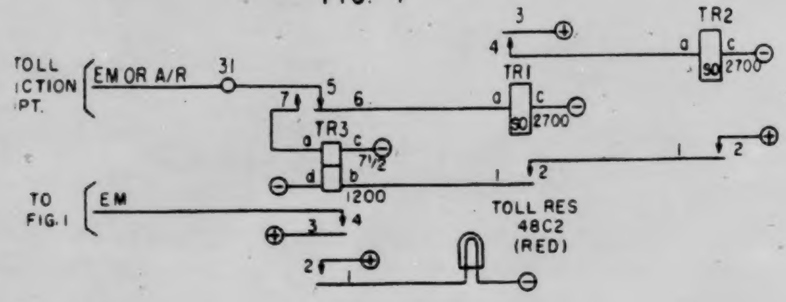


FIG. 4



36251 04 S03 7603

Foldout 4

BTM 4

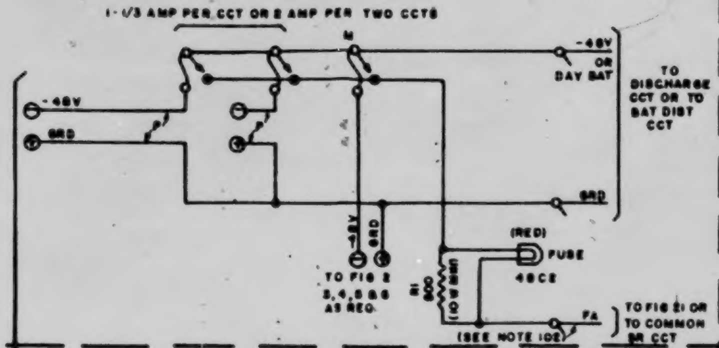
AU GAFS,AL(784134)1M

490
FO. 4

LT 1

SHELF SUPERVISORY EQPT PER SHELF

FIG 1



1-1/3 AMP PER CCT OR 2 AMP PER TWO CCTS
M
-48V
GRD
-48V OR BAY BAT
TO DISCHARGE CCT OR TO BAT DIST CCT
GRD
-48V
GRD
TO FIG 2 3,4,5 & 6 AS REQ
R1 500 (10 W MIN)
(RED) FUSE 48C2
FA
TO FIG 21 OR TO COMMON SR CCT
(SEE NOTE 102)
TO SHELF EQPT

FIG. 2 OR 2A
RELEASE ALARM

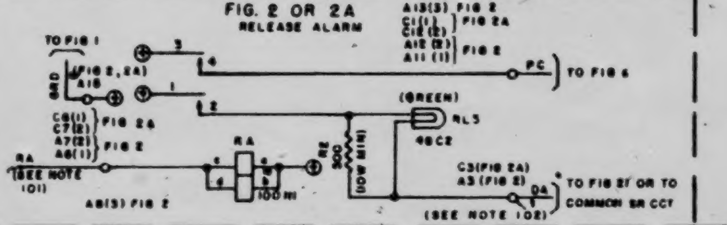


FIG 3
RELEASE ALARM FOR SELECTOR SHELVES HAVING TWO GROUPS OF SELECTORS

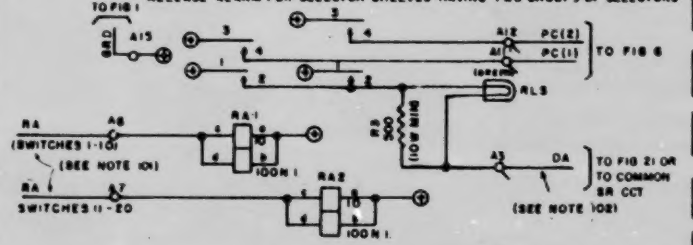
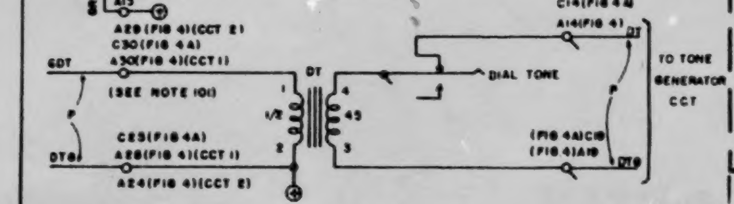


FIG 4 OR 4A
DIAL TONE

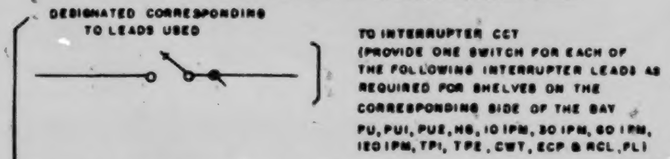


512

SHELF SUPERVISORY EQPT PER SIDE OF A BAY OF SHELVES

(NOT USED ON CONNECTOR SYSTEMS)

FIG. 11
TOGGLE SWITCHES FOR INTERRUPTED GROUND LEADS



DESIGNATED CORRESPONDING TO LEADS USED
TO INTERRUPTER CCT
(PROVIDE ONE SWITCH FOR EACH OF THE FOLLOWING INTERRUPTER LEADS AS REQUIRED FOR SHELVES ON THE CORRESPONDING SIDE OF THE BAY
PU, PU1, PU2, HG, 10 IPM, 30 IPM, 60 IPM, 120 IPM, TP1, TP2, CWT, ECP & RCL, FL1)

FIG 12 (SEE NOTE 108)
TOGGLE SWITCHES FOR TONE LEADS
(PROVIDE SWITCHES ONLY AS REQ FOR SHELVES ON CORRESPONDING SIDE OF THE BAY)

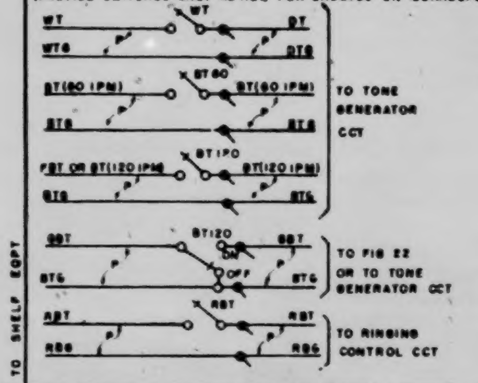
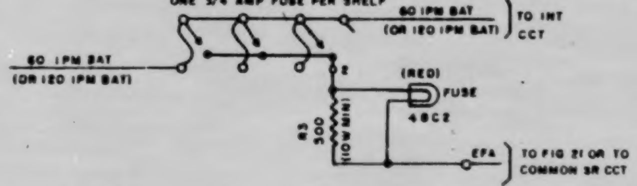
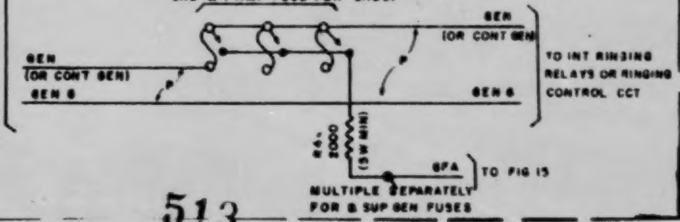


FIG 13 (SEE NOTE 104) (SEE NOTE 108)
FUSING FOR INTERRUPTED BATTERY LEADS
ONE 3/4 AMP FUSE PER SHELF



60 IPM BAT (OR 120 IPM BAT)
TO INT CCT
60 IPM BAT (OR 120 IPM BAT)
2
(RED) FUSE 48C2
R3 500 (10 W MIN)
EFA
TO FIG 21 OR TO COMMON SR CCT

FIG 14 (SEE NOTE 108)
BAT CONNECTED GENERATOR FUSING (PROVIDE ONE FIG 15 PER GENERATOR LEAD)
ONE 3/4 AMP FUSE PER SHELF



GEN (OR CONT GEN)
TO INT RINGING RELAYS OR RINGING CONTROL CCT
GEN (OR CONT GEN)
GEN G
GEN G
R4 2000 (5 W MIN)
GFA
TO FIG 15
MULTIPLE SEPARATELY FOR B SUP GEN FUSES

513

491
FC.5

LT2

FIG 5

• ATB RELAY

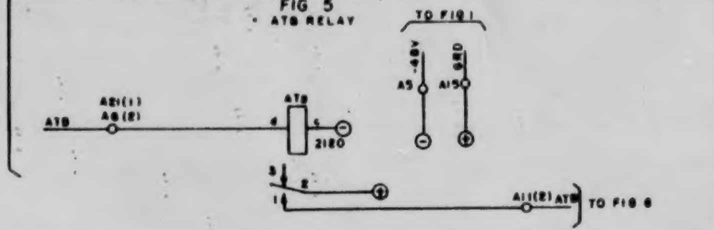


FIG 6

PC OR ATB METER

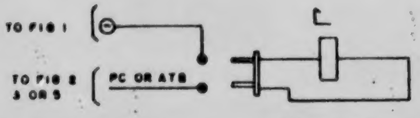


FIG 7

COIN CONTROL BATTERY

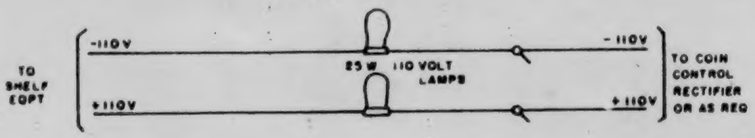


FIG 8

INSULATED GEN LAMPS

(ONE PER SHELF OR PER 10 CCTS OR LESS)

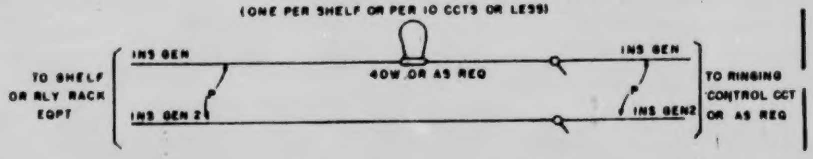
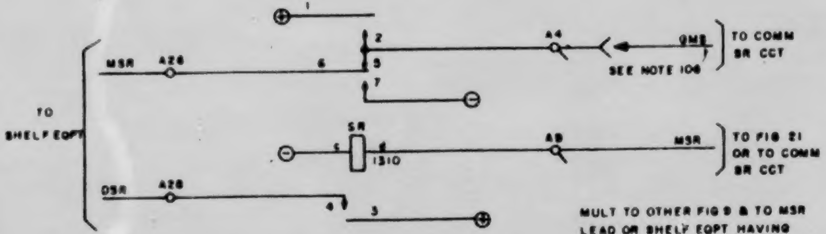


FIG 9

(SEE NOTE 103 OR 109)
SUPERVISORY RELAY FOR SHELF EQPT NOT
HAVING BATTERY CONNECTED MON LAMPS



MULT TO OTHER FIG 9 & TO MSR LEAD OR SHELF EQPT HAVING BATTERY CONNECTED MON LAMPS

FIG 15 (SEE NOTE 108)

GENERATOR FUSE ALARM (ONE PER SIDE OF BAY USING FIG 14)

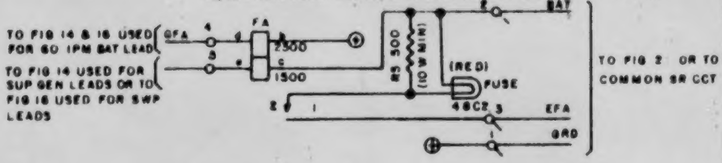


FIG 16 (SEE NOTE 108)

FUSING FOR 60 IPM BAT OR SWP LEADS
ONE 3/4 AMP FUSE PER SHELF

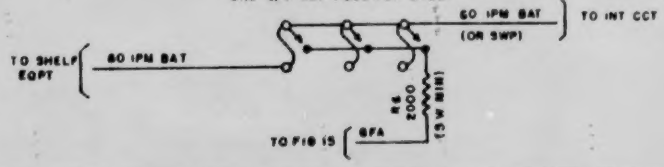
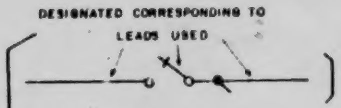


FIG 17 (SEE NOTE 108)

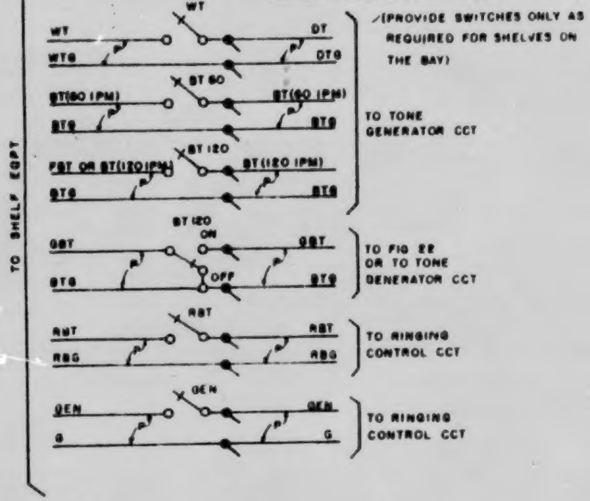
TOGGLE SWITCHES FOR INTERRUPTED LEADS



C INTERRUPTER CCT
(PROVIDE ONE SWITCH FOR EACH OF THE FOLLOWING INTERRUPTER LEADS AS REQUIRED FOR SHELVES ON THE BAY
PU,PU1, PU2, HG, 10 IPM, 30 IPM, 60 IPM, 120 IPM, TP1, TP2, CWT, ECP, RCL, FL, SWP 60 IPM, BAT & 120 IPM BAT)

FIG 18 (SEE NOTE 108)

TOGGLE SWITCHES FOR LEADS



✓(PROVIDE SWITCHES ONLY AS REQUIRED FOR SHELVES ON THE BAY)

492
EC.5

LT3

FIG 10

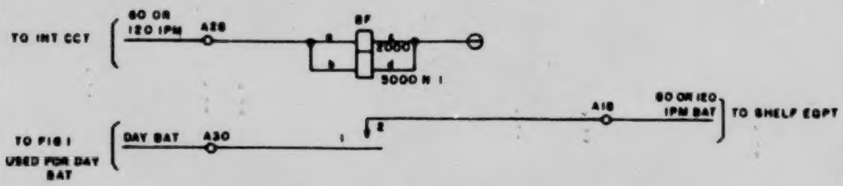


FIG 19

FUSE ALARM RELAY
FOR EXTENDING ALARM
(USED WITH FIG 1)

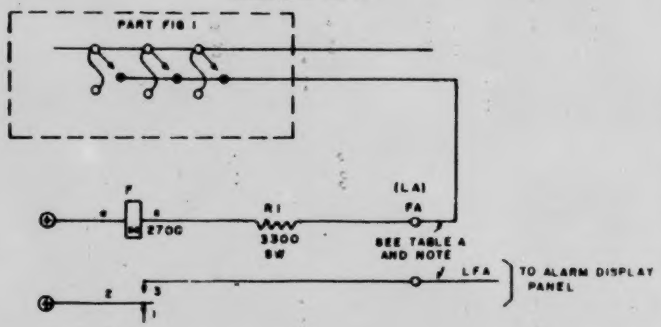


TABLE "A"				
CCT	FA	LFA	LA	LFA
1	C1	C6	A1	A6
2	C2	C7	A2	A7
3	C3	C8		
4	C4	C9		
5	C16	C21		
6	C17	C22		
7	C18	C23		
8	C19	C24		

NOTE

USE "C" TERMINATION FOR USE WITH OTHER FIGURES OF THIS CIRCUIT ON SAME PLATE USE "A" TERMINATIONS WHEN FIGURE 19 IS USED ALONE

493
Fo. 5

494
F0.5

ROW SUPERVISORY EQPT

(ONE PER ROW OF BAYS END TO END)

GROUP SUPERVISORY EQPT

(ONE PER GROUP OF BAYS)

FIG. 21
ALARM PILOT EQPT & MONITOR LAMP CONTROL SWITCHES

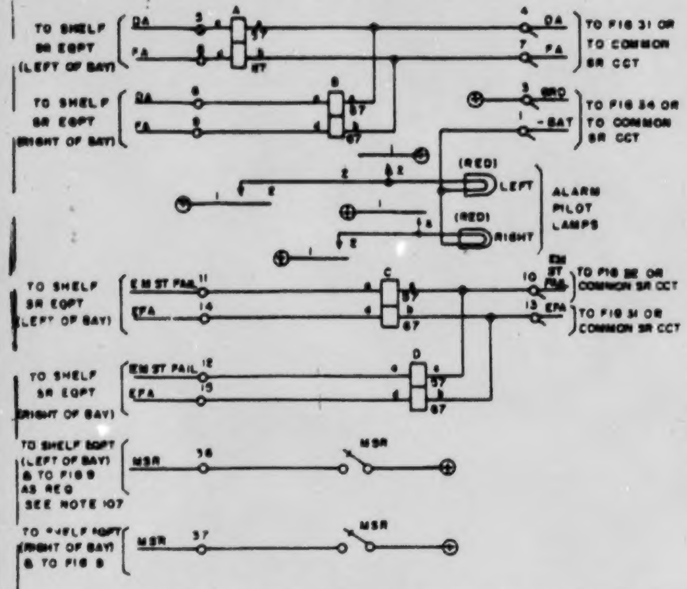
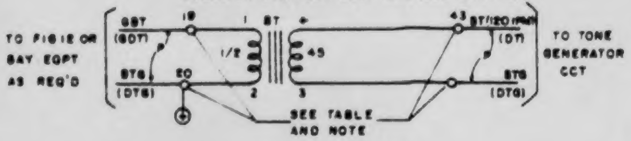

TO SHELF SR EQPT (LEFT OF BAY)
DA
FA
TO FIG 31 OR TO COMMON SR CCT
TO SHELF SR EQPT (RIGHT OF BAY)
GRD
-BAT
TO FIG 34 OR TO COMMON SR CCT
(RED)
LEFT
(RED)
RIGHT
ALARM PILOT LAMPS
TO SHELF SR EQPT (LEFT OF BAY)
EM ST FAIL
EFA
TO FIG 32 OR COMMON SR CCT
TO FIG 31 OR COMMON SR CCT
TO SHELF SR EQPT (RIGHT OF BAY)
EM ST FAIL
EFA
TO SHELF EQPT (LEFT OF BAY) & TO FIG 9 AS REQ SEE NOTE 107
MSR
TO SHELF EQPT (RIGHT OF BAY) & TO FIG 9
MSR

FIG 22 (GRP DIAL TONE CCT AS REQ'D)
SELECTOR OVERFLOW BUSY TONE (SEE NOTE 103)



FOR USE ON CENTRALIZED EQUIPMENT ONLY

CCT	GBT OR BDT	BTG OR DTG	BT OR DT	BTG OR DTG
1	A1	A6	A3C	A25
2	A11	A16		
3	A21	A26		
4	A2	A7		
5	A12	A17		

FIG. 31
FUSE & RELEASE ALARM

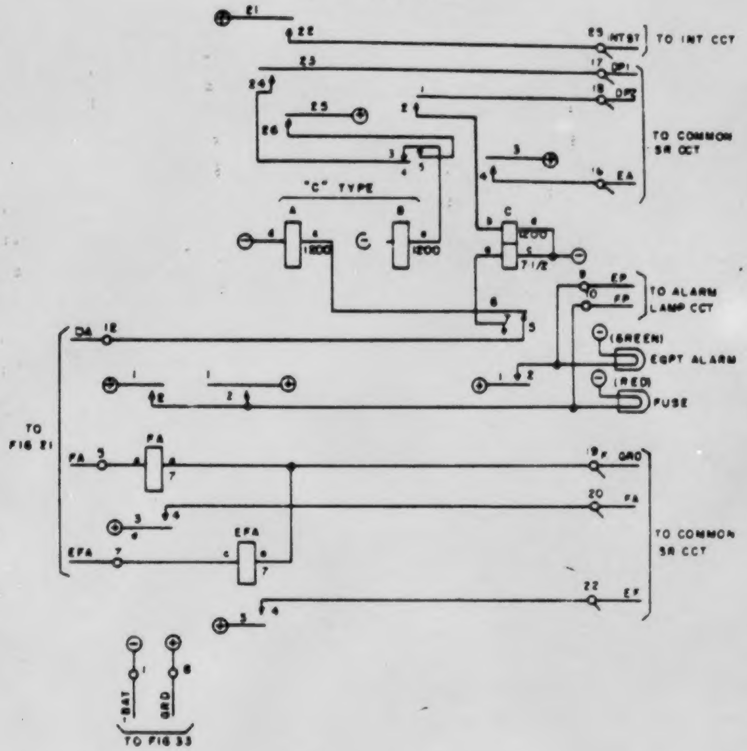
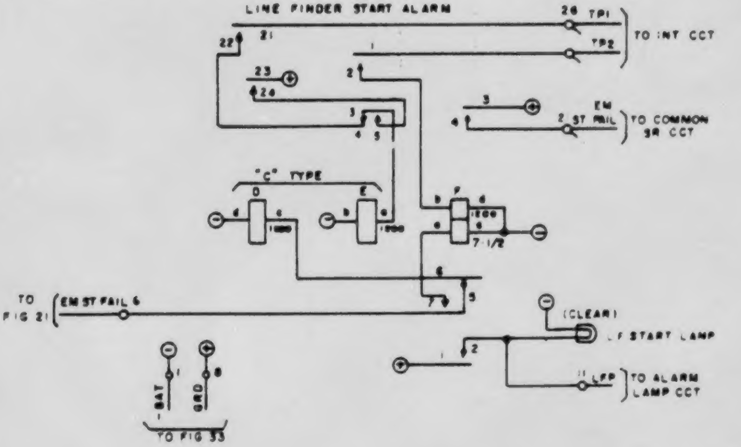


FIG 32
LINE FINDER START ALARM



RT 1

FIG 33

FUSING FOR GROUP SUPERVISORY EQPT

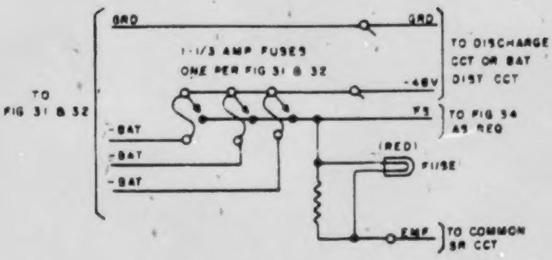


FIG 34

FUSING FOR AISLE ALARM LAMPS

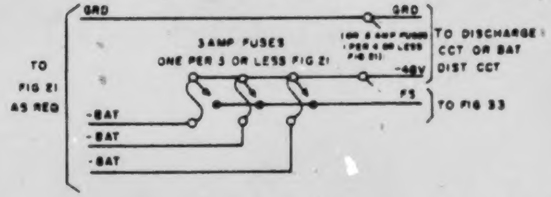
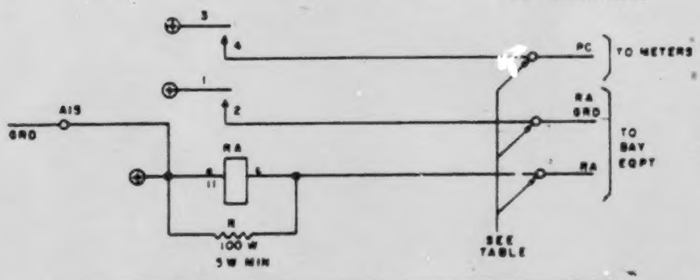


FIG 35

RELEASE ALARM
(CENTRALIZED EQPT)



	CCT	1	2	3	4	5	6	7	8	9	10
RA GRD		A1	A2	A3	A4	A11	A12	A13	A14	A21	A22
RA		A6	A7	A8	A9	A16	A17	A18	A19	A26	A27
PC	PC	C1	C2	C3	C4	C11	C12	C13	C14	C21	C22

101 – RA & GDT LEADS ARE WIRED TO FRAME JACK BUSY SWITCH WHICH CONNECTS GROUND TO THEM WHEN SUPERVISORY CIRCUIT PLATE IS REMOVED

102 – WHEN FIG 21 IS USED FA LEADS ARE MULTIPLIED ONLY WITH OTHER FA LEADS FROM SHELVES ON SAME SIDE OF BAYS IN SAME ROW, AND DA, EFA & EM ST FAIL LEADS SHALL BE MULTIPLIED IN SIMILAR MANNER

103 – USE FIG 22 ONLY WHEN TONE GENERATOR IS NOT EQUIPPED WITH SELECTOR OVERFLOW BUSY TONE COIL

104 – WHEN 60 IPM BAT OR SWP LEAD IS USED ON BAY EQUIPPED WITH FIG 14 & 15, USE FIG 16 FOR FUSING OF 60 IPM BAT & SWP LEADS

105 – ON SHELVES WHICH HAVE MONITOR LAMPS THAT ARE NOT BATTERY CONNECTED USE FIG 9 OMIT FIG 9 ON SHELVES WHICH HAVE BATTERY CONNECTED MONITOR LAMPS

106 – USE GMS LEAD WHEN ASSOCIATED SHELF EQPT REQUIRES START OF TONE RINGING OR INTERRUPTER EQPT & IS NOT EQPD WITH START LEAD, OTHERWISE OMIT GMS LEADS

107 – MSR LEAD OF FIG 21 CONNECTS TO MSR LEAD OF SHELF EQPT ONLY ON SHELVES HAVING BATTERY CONNECTED MONITOR LAMPS ON SHELVES HAVING MONITOR LAMPS NOT BATTERY CONNECTED. MSR LEADS OF FIG 21 CONNECTS TO COIL OF SR RELAY OF FIG 9

108 – WITH ISSUE 8 FIG 17 & 18 SUPERSEDE FIG'S 11, 12, 13, 14 & 15 ON NEW JOBS, AS REQUIRED ON PBX SELECTOR SYSTEMS WHERE THE GENERATOR IS NOT FUSED ON THE POWERBOARD FIG 21 OF 9-90276 WILL BE USED ON NEW JOBS

.09 – FOR SUPV SHELVES EQUIPPED WITH BATTERY CONNECTED MONITOR LAMPS STRAP A26 TO A8

Foldout 6

AU GAFS, AL (801040)1100

FIG I

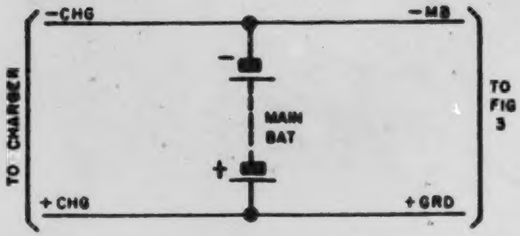
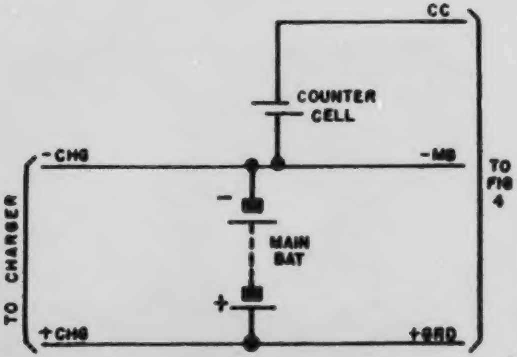


FIG 2



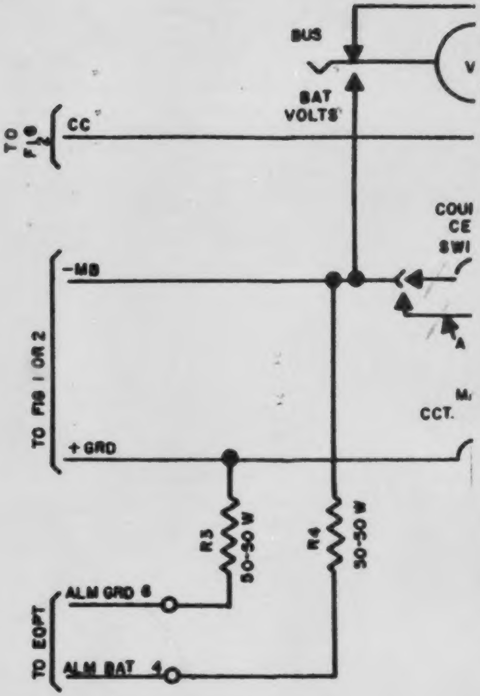


FIG 5

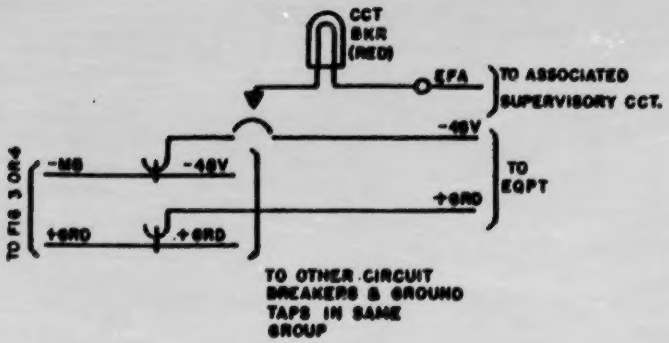
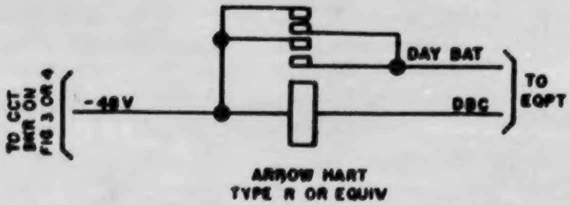
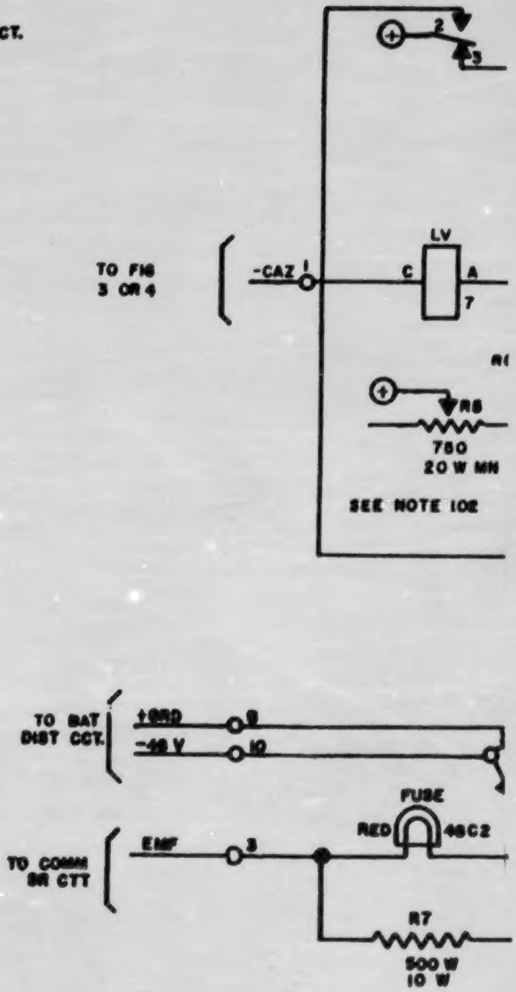

CCT
BKR
(RED)
EFA
TO ASSOCIATED
SUPERVISORY CCT.
-48V
TO
EQPT
-MB
-48V
+GRD
+GRD
+GRD
TO FIG 3 OR 4
TO OTHER CIRCUIT
BREAKERS & GROUND
TAPS IN SAME
GROUP

FIG 6


DAY BAT
TO
EQPT
-48V
DBC
TO CCT
BKR ON
FIG 3 OR 4
ARROW HART
TYPE R OR EQUIV


2
3
TO FIG
3 OR 4
-CAZ
1
LV
C
A
7
R8
750
20 W MN
SEE NOTE 102
TO BAT
DIST CCT.
+GRD
9
-48 V
10
FUSE
RED
46C2
TO COMM
BR CTT
EMF
3
R7
500 W
10 W

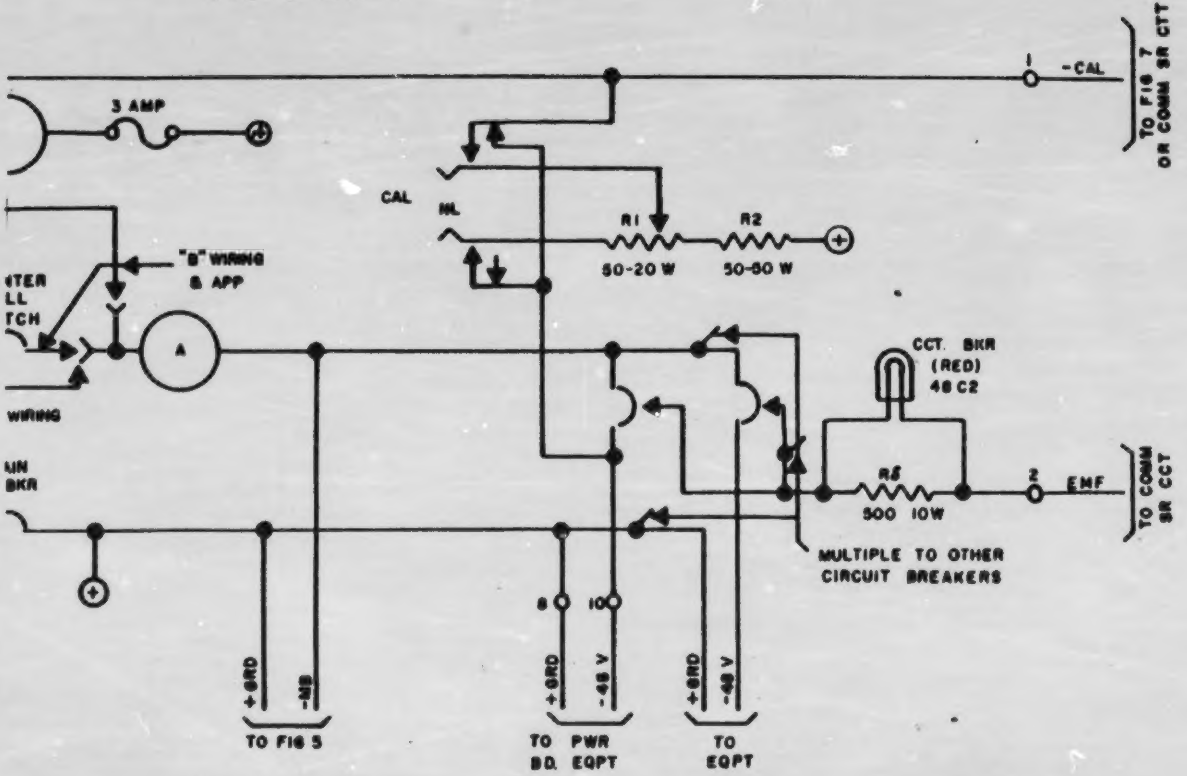
TP 2

NOTES

101- ALARM CONTACTS OF CIRCUIT BREAKERS CLOSE ONLY WHEN ELECTRICALLY TRIPPED

102- RESISTOR R5 SHALL BE ADJUSTED TO RELEASE RELAY LV ON 47 VOLTS WITH CONTACTS 1 & 2 OF RELAY VB OPEN

FIG 3 OR 4



BTM 2

FIG 7

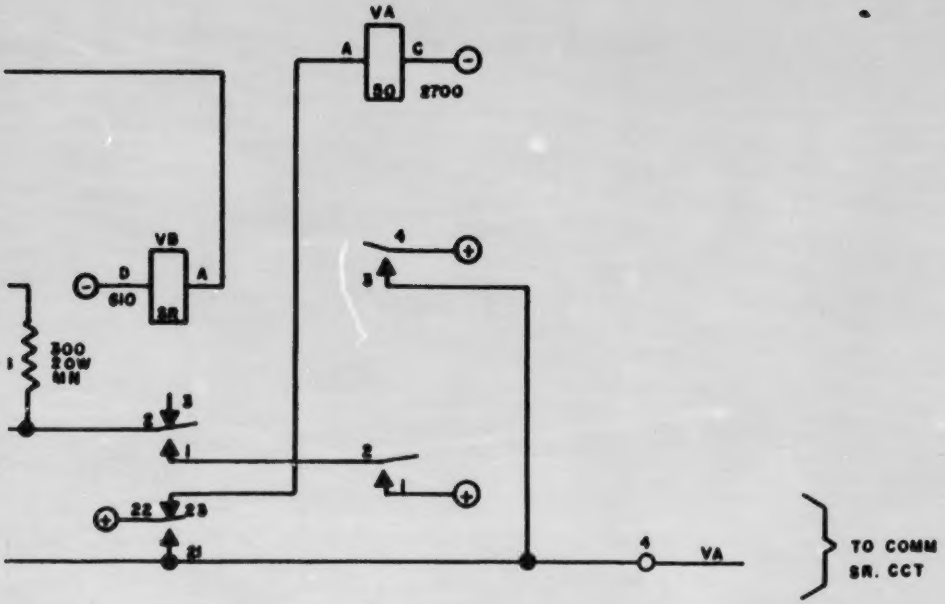


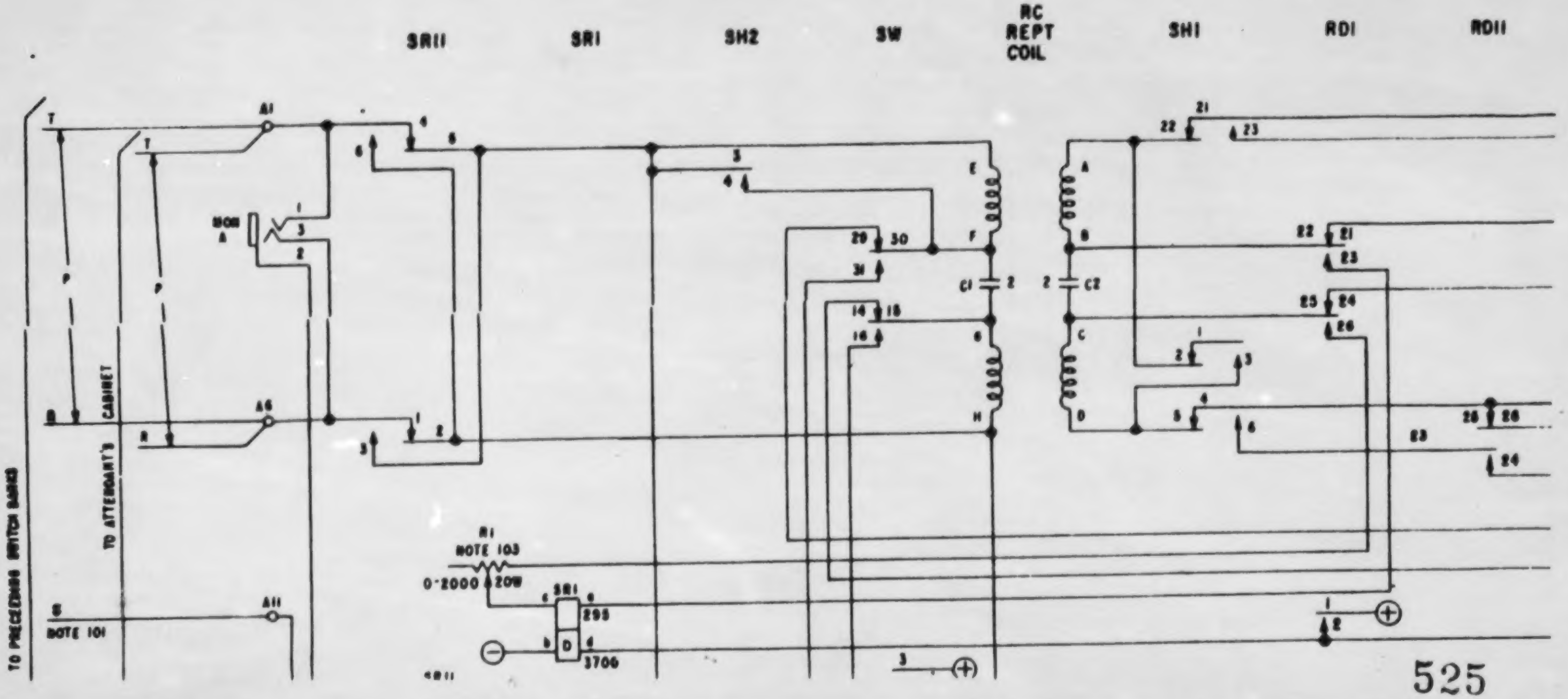
TABLE A		
FIG	PURPOSE	OPTION
3	DISCHG & DIST NO COUNTER CELL	A
4	DISCHG & DIST FOR COUNTER CELL	B

LT 1

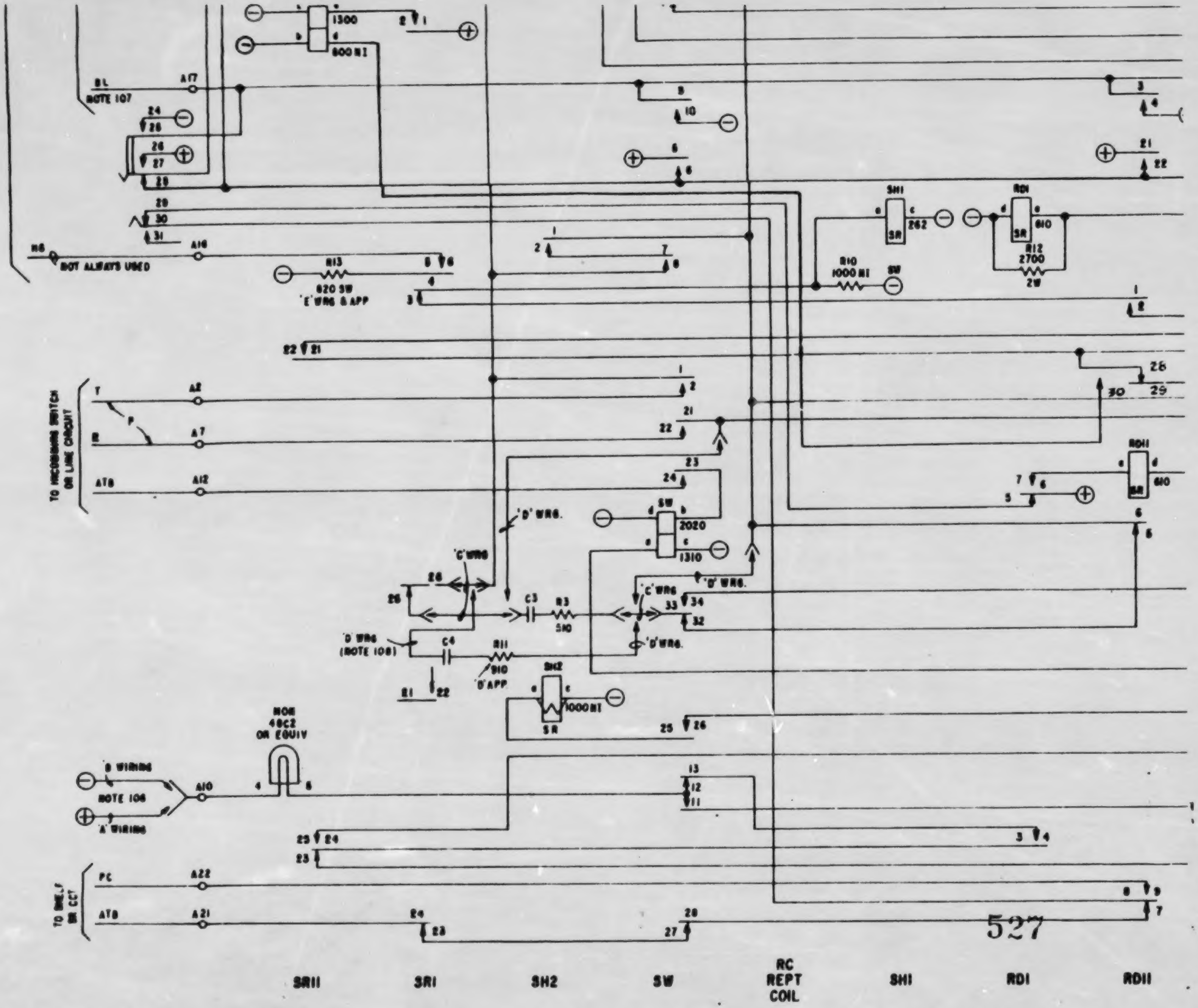
36251 04 S06 7603

Foldout 10

FIG. 1, 2 OR 3 (USE C WIRING
FIG. 6, 7 OR 8 (USE D WIRING
FIG. 9-14 SEE NOTE III

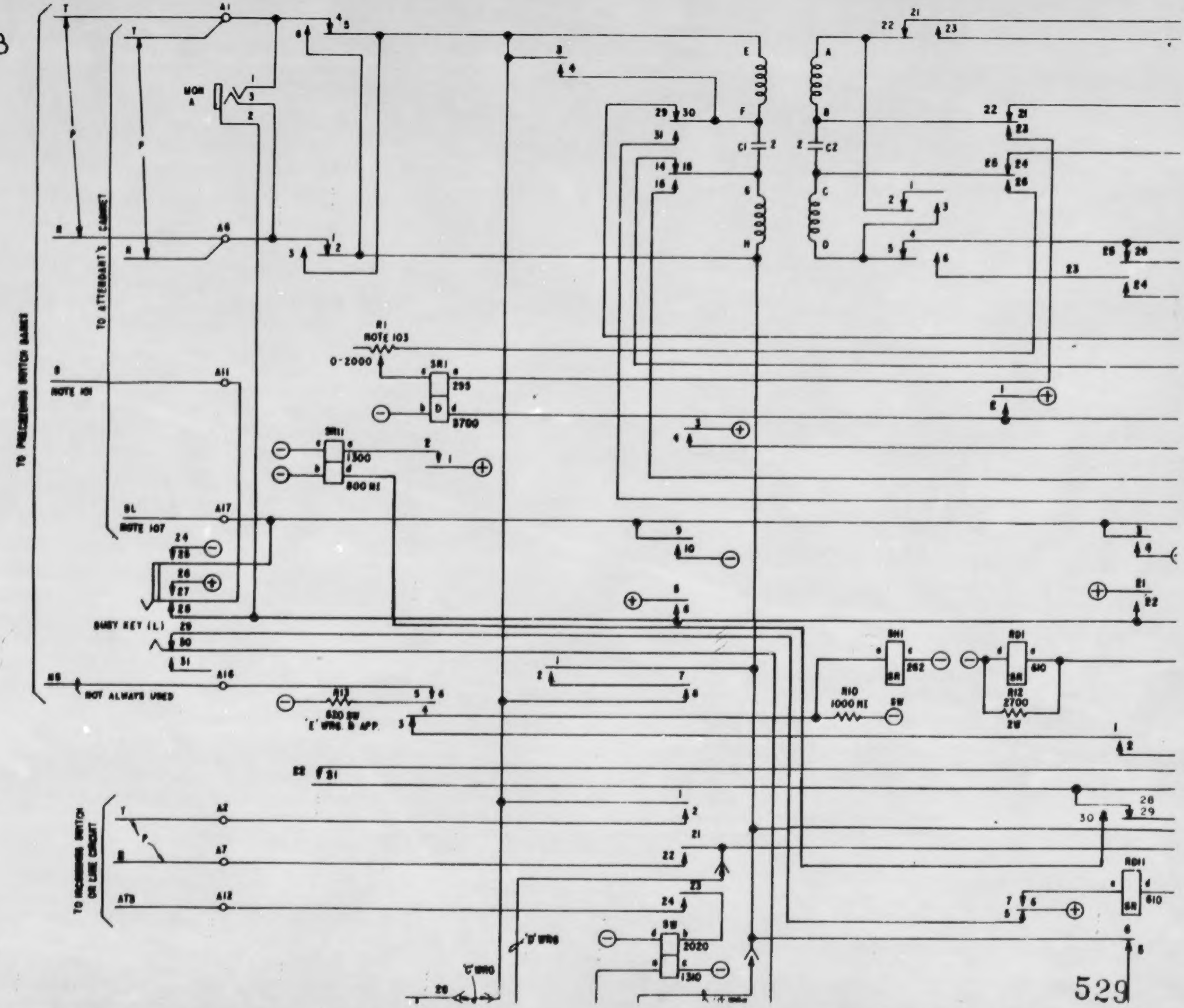


LT 2


1300
800 NI
BL
NOTE 107
A17
NG
NOT ALWAYS USED
A16
R13
820 5W
'E' WRG & APP
SH1
262
RD1
SR
610
R10
1000 NI
SW
R12
2700
2W
TO PROCESSING SWITCH OR LINE CIRCUIT
T
R
ATB
A2
A7
A12
P
'D' WRG.
'C' WRG
SW
2020
1310
C3
R3
510
C4
R11
510
'D' APP.
'D' WRG
(NOTE 108)
SH2
1000 NI
RD11
610
NON
48C2
OR EQUIV
B WIRING
NOTE 106
'A' WIRING
A10
TO SHELF OR CCT
PC
ATB
A22
A21
SRII
SRI
SH2
SW
RC
REPT
COIL
SHI
RDI
RDII

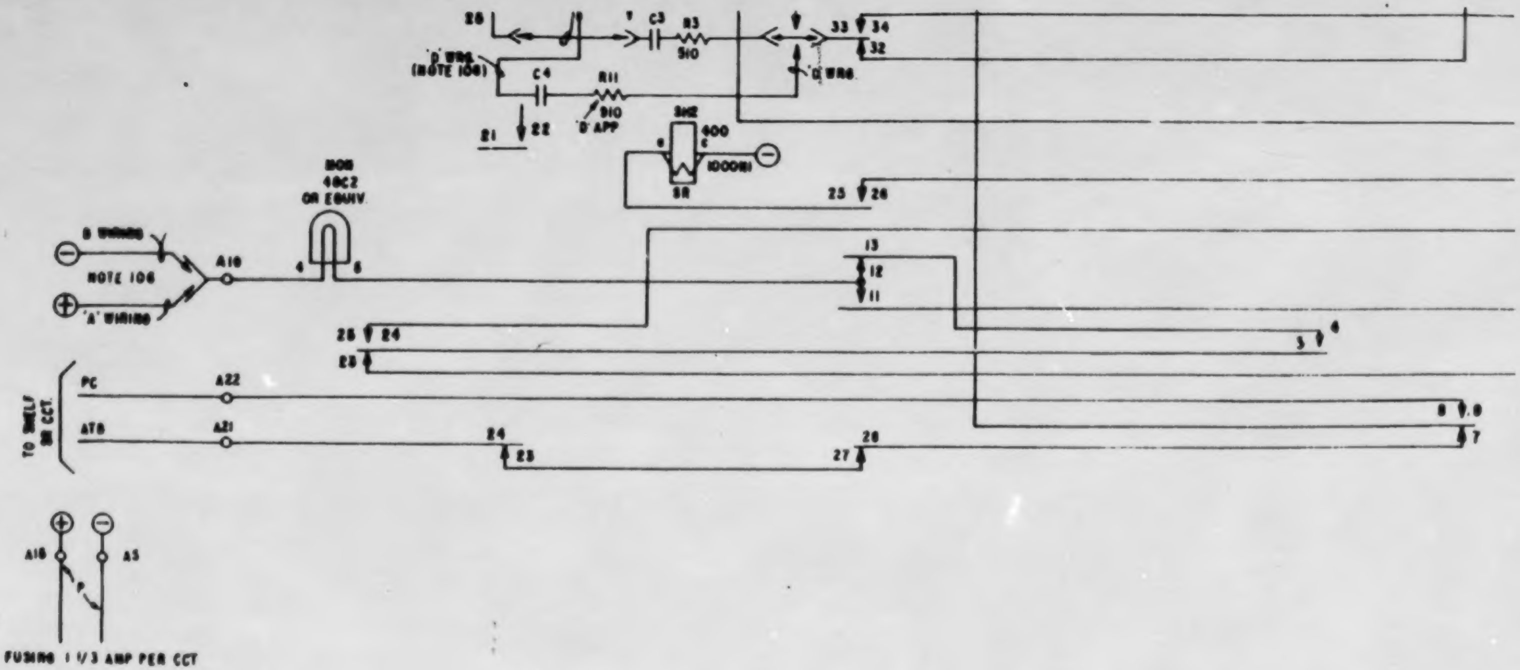
5DL
Fo.10

LT 3


TO PRECEDING SWITCH BANKS
TO ATTENDANT'S CABINET
T
R
P
A1
A6
MON A
E
F
G
H
C1
C2
A
B
C
D
R1
NOTE 103
0-2000
SR1
295
D
3700
S
NOTE 101
A11
SR11
1300
800 NI
BL
NOTE 107
A17
BUSY KEY (L)
HS
NOT ALWAYS USED
A16
R13
620 5W
'E' WRG. & APP.
SH1
SR
262
RD1
SR
610
R10
1000 NI
SW
R12
2700
2W
TO INCOMING SWITCH OR LINE CIRCUIT
A2
A7
ATB
A12
'D' WRG
'C' WRG
SW
2020
1310
RD11
SR
610

5C2
FO. 10

LT 4



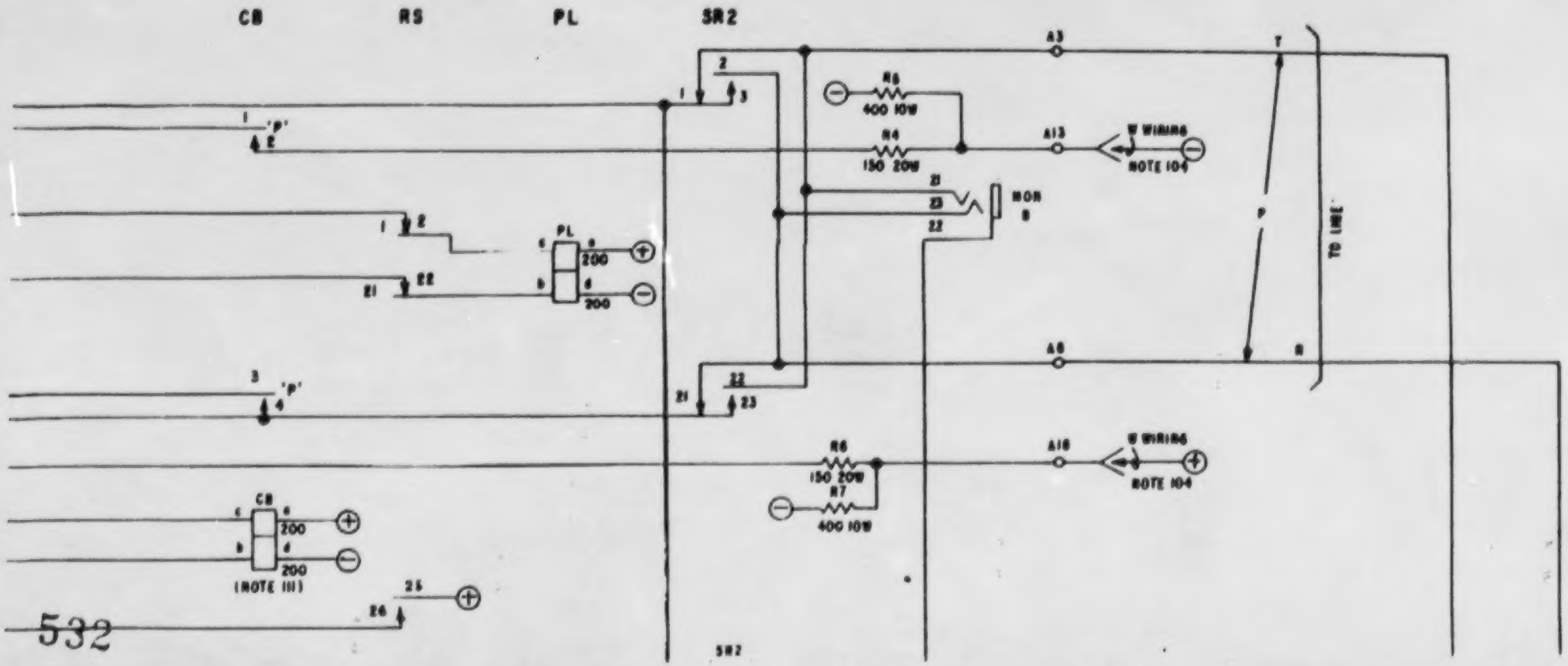
531

5C3
Fo.10

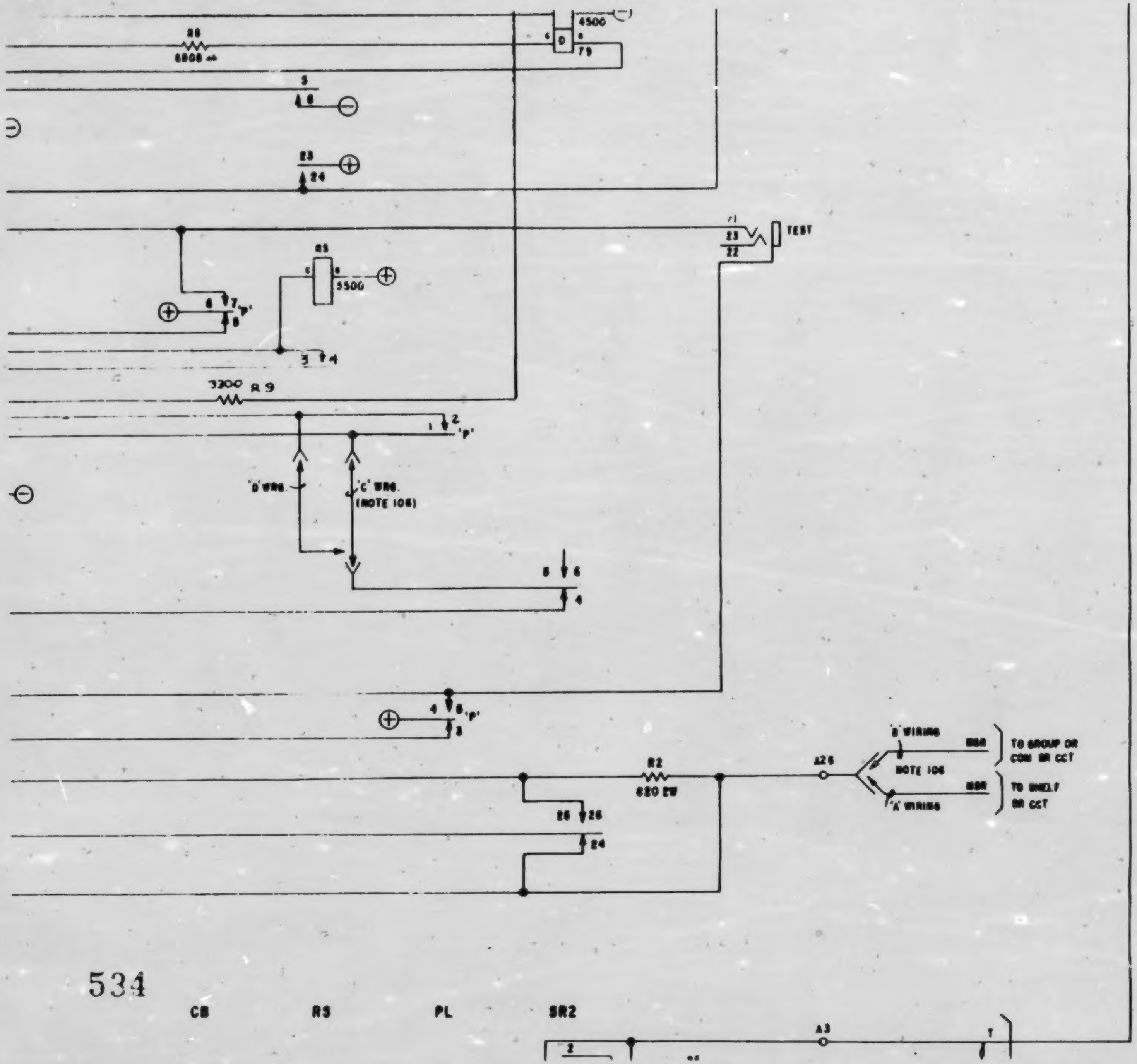
530

RT1

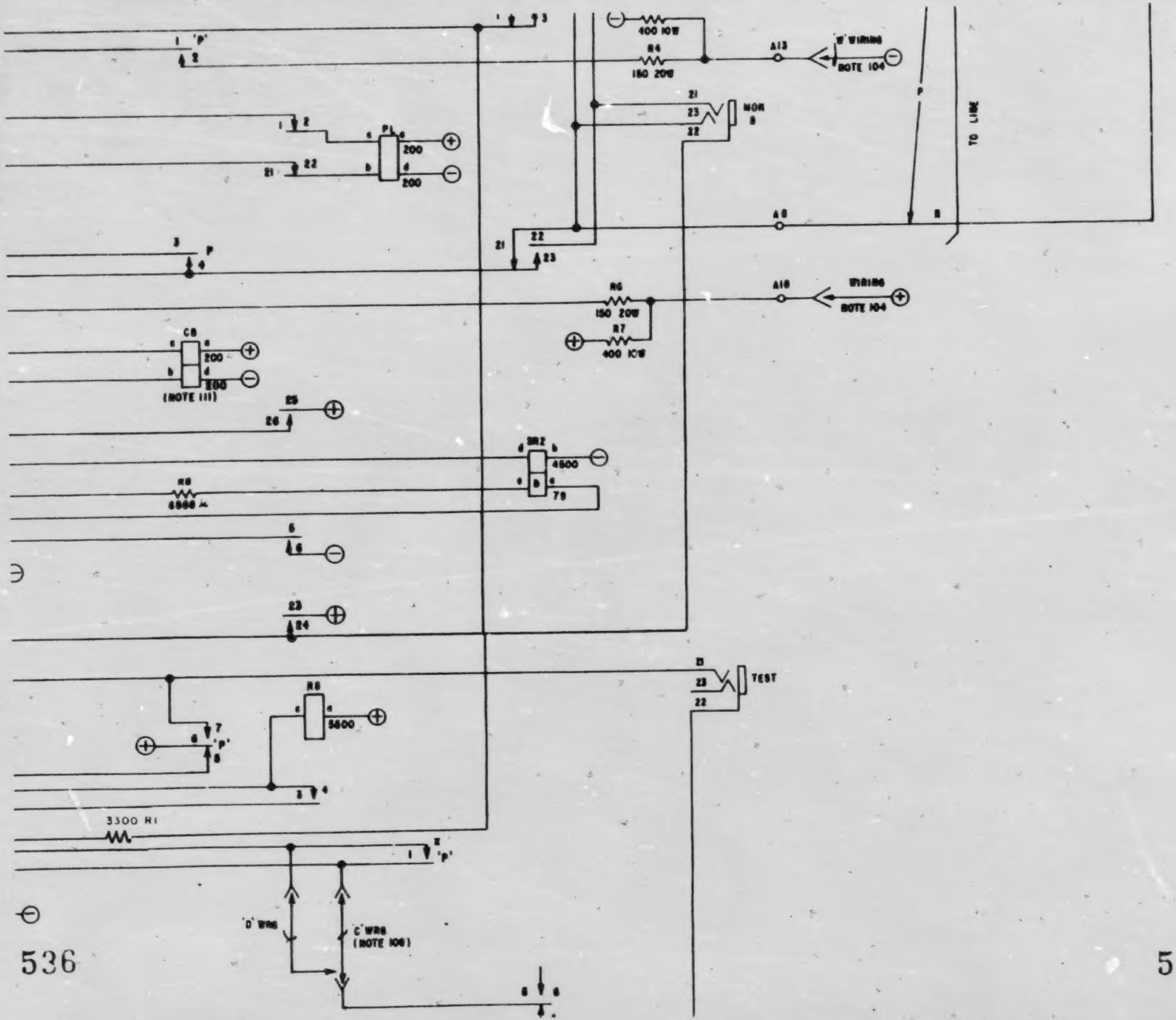
& OMIT D WIRING & APP)
& APP & OMIT C WIRING) SEE NOTES 102 & 108

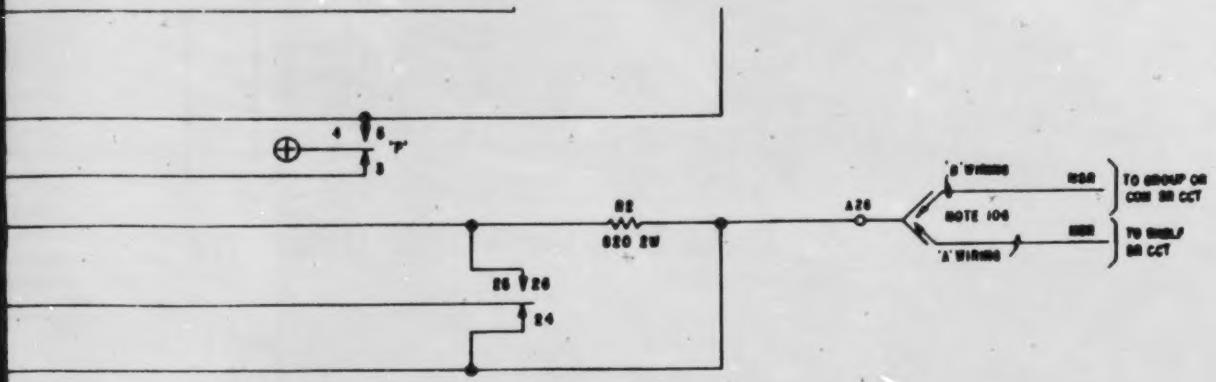


RT 2


R8
6808
4500
D
79
5
6
23
24
11
23
22
TEST
R3
5500
6
7 'P'
8
3
4
3200 R 9
1
2 'P'
'D' WRG.
'C' WRG.
(NOTE 106)
5
6
4
4
5 'P'
3
R2
820 2W
25
26
24
A26
'B' WIRING
NOTE 106
'A' WIRING
MBR
TO GROUP OR COM BR CCT
MBR
TO SHELF BR CCT
CB
RS
PL
SR2
A3
T
2

RT3


1 'P' 2
1 2 3
400 10W
R4
150 20W
A13
'B' WIRING
NOTE 104
21
23
22
MON
8
1 2
PL
200
21 22
200
A8
P
R
TO LINE
21
22
23
3 P
4
R6
150 20W
A10
WIRING
NOTE 104
R7
400 10W
CB
200
200
(NOTE 111)
25
26
SR2
4500
R8
6800
D
79
5
6
23
24
21
23
22
TEST
RS
5600
7
'P'
8
3 4
3300 R1
2
1 'P'
'D' WRG
'C' WRG
(NOTE 108)
5 6



NOTES

101 - THE 'S' LEAD IS WIRED THRU THE FRAME JACK BUSY SWITCH SO THAT THE REMOVAL OF THE CIRCUIT PLATE CONNECTS IT TO GRD.

102 - SPECIFY A FIGURE FROM "TABLE A" TO PROVIDE A TRUNK CIRCUIT WITH THE REQUIRED REPEAT COIL.

103 - ADJUST RESISTOR R-1 TO 2000 OHMS MINUS TRUNK LOOP RESISTANCE ± 50%.

104 - SPECIFY THE REMOVAL OF "W" WIRING IF TRUNK LOOP RESISTANCE IS LESS THAN 1000 OHMS UNLESS OTHERWISE SPECIFIED, "W" WIRING SHALL BE PROVIDED FOR TRUNK LOOPS OF 1000 TO 2000 OHMS.

105 - CODE "P" CONTACTS ARE INDICATED BY THE LETTER "P".

106 - SPECIFY "B" & OMIT "A" WIRING FOR BATTERY CONNECTED MONITOR LAMP UNLESS OTHERWISE SPECIFIED USE "A" WIRING & OMIT "B" WIRING.

107 - THE BL LEAD IS WIRED THRU FRAME JACK BUSY SWITCH SO THAT THE REMOVAL OF THE CIRCUIT PLATE CONNECTS IT TO BATTERY.

108 - PRIOR TO ISSUE 3, "C" WIRING WAS PART OF FIGS 1, 2 & 3, & "D" WIRING & APP. & FIGS 6,7 & 8 WERE NOT SHOWN. WITH ISSUE, 3 "C" WIRING REMAINS PART OF FIG'S 1,2 & 3, & "D" WIRING & APP BECOME PART OF FIG'S 6,7 & 8. SPECIFY FIG 1,2 OR 3 WHEN 600 OHM IDLE LINE TERMINATION IS REQUIRED. SPECIFY FIG 6,7 OR 8 WHEN 900 OHM IDLE LINE TERMINATION IS REQUIRED.

STOP-

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 2 PENCIL ONLY.

36251 04 23

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

XY TELEPHONE SYSTEM

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DONT'S:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers.* The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

Multiple Choice

1. (600) How many circuit plates in an XY linefinder shelf contain line circuits?

   a. 8.
   b. 10.
   c. 12.
   d. 14.

2. (600) In an XY linefinder shelf, how many linefinder circuit plates do not contain line circuits?

   a. 0.
   b. 2.
   c. 3.
   d. 4.

3. (600) How many connections are there from an XY line circuit to the connector banks?

   a. 2.
   b. 3.
   c. 4.
   d. 5.

4. (601) How many allotters would be found in a 1,000-line XY exchange?

   a. 2.
   b. 8.
   c. 10.
   d. 20.

5. (602) Which of the following statements is not correct?

   a. In an XY line circuit, ten lines are connected to a common AST lead.
   b. In an XY line circuit, each AST lead is connected to the X-XX bank.
   c. In an XY line circuit, the even-numbered AST leads are connected to the X bank.
   d. In an XY line circuit, if one allotter fails, the other allotter will handle all line circuits.

6. (602) The odd-numbered lines in an XY exchange are connected to the

   a. X bank.
   b. XX bank.
   c. even levels.
   d. S and HS leads.

7. (602) What bank is marked with a potential when line 32 goes off-hook?

   a. X wire bank, third contact with ground.
   b. XX wire bank, third contact with ground.
   c. X wire bank, second contact with battery.
   d. XX wire bank, second contact with battery.

8. (602) If a call originates from a station on an even-numbered line to an XY exchange, ground is placed on an X bank wire through the contacts of the transfer relay in allotter A when

   a. the XX bank is busy.
   b. allotter B is inoperative.
   c. allotter A is operating properly.
   d. relay CO is operated because of a grounded S lead.

9. (602) If a call originates from a station on an odd-numbered line to an XY exchange, ground is placed on an XX bank wire through contacts of the transfer relay in allotter B when

   a. the X bank is busy.
   b. allotter A is inoperative.
   c. allotter B is inoperative.
   d. both allotters are functioning properly.

10. (602) Position on a level in XY exchange linefinder circuits is marked by applying negative battery to the

a. T lead.
b. R lead.
c. S bank wire.
d. HS bank wire.

11. (603) Refer to figure 1-1 of the text. Which closed contacts mark a line busy at the connector bank?

a. 23 and 24 of relay CO.
b. 3 and 4 of relay LR.
c. 25 and 26 of relay CO.
d. 6 and 7 of relay LR.

12. (604) What lead is marked with ground, to act along with succeeding equipment for restricted service, when a subscriber whose line circuit is strapped for restricted service dials a restricted level?

a. T.
b. R.
c. HS.
d. XX.

13. (605) In an all-linefinder-busy condition in an XY exchange,

a. the ATB lead is grounded in allotter A.
b. the ATB lead is grounded in allotter B.
c. one ground is removed from the ATB lead.
d. all grounds are removed from the ATB lead.

14. (605) Refer to foldout 1. When a handset of a telephone in an XY system is lifted, relay

a. FB operates.
b. SA operates.
c. SA releases.
d. FB releases.

15. (605) Relay GD (FO 1) operates in series with

a. relay SA.
b. the X magnet.
c. the Y magnet.
d. the rotary switch magnet.

16. (605) What action in the linefinder (FO 1) preseizes the associated selector?

a. Operation of relay SW.
b. Operation of relay CO.
c. The closing of contacts 27 and 28 of the SW relay.
d. The closing of contacts 1 and 2 of the ST relay.

17. (605) Refer to foldout 1. Operation of relay PA in the linefinder-allotter circuit of an XY exchange

a. closes the XY-ON circuit.
b. stops Y-direction stepping.
c. starts X-direction stepping.
d. locks the X-XX wiper in position.

18. (606) What relay in the allotter (FO 1) does the X magnet work to control X-direction stepping?

a. YD.
b. SA.
c. PA.
d. AS.

19. (606) What potential operates the XS relay in the allotter circuit (FO 1) if line circuit 48 goes off-hook?

a. Ground on the X wire bank.
b. Ground on the XX wire bank.
c. Battery on the X wire bank.
d. Battery on the XX wire bank.

20. (607) Refer to foldout 1. Operation of the Y magnet causes the Y interrupter springs in the linefinder-allotter circuit of an XY exchange to

    a. further open the circuit of relay SW.
    b. open the operating circuit of relay PA.
    c. close the circuit of relay GD and open the circuit of rotary switch A.
    d. transfer the operating circuit of relay AS from the bd to the ca winding.

21. (607) Refer to foldout 1. What two elements control the Y stepping in an XY linefinder?

    a. YD relay and PA relay.
    b. YD relay and XS relay.
    c. YD relay and Y interrupter springs.
    d. Y interrupter springs and PA relay.

22. (607) Which relay action in the allotter (FO 1) causes the ST relay in the linefinder to release?

    a. YD relay releasing.
    b. SA relay operating.
    c. YS relay operating.
    d. GD relay releasing.

23. (607) What lead from a busy linefinder circuit causes the rotary switch (FO 1) to step over it?

    a. G.
    b. DA.
    c. ATB.
    d. ST-A.

24. (608) What action restores an operated linefinder release magnet (FO 1)?

    a. Restoring of Y-ONs.
    b. Restoring of X-ONs.
    c. Operation of Y-ONs.
    d. Operation of X-ONs.

25. (608) Release of the Z spring pileup in a linefinder switch (FO 1) results in which of the following?

    a. Removes ground from the G lead.
    b. Marks the allotter busy to calls.
    c. Releases the associated selector.
    d. Marks the switch busy to the rotary switch.

26. (609) The action of which of the following initially removes a ground from the ATB lead during call processing by a linefinder (FO 1)?

    a. Relay ST.
    b. Relay SW.
    c. X-ONs.
    d. Y-ONs.

27. (610) Refer to foldout 1. There is a ground pulse on the PU lead about every

    a. 2 seconds.
    b. 3 seconds.
    c. 4 seconds.
    d. 6 seconds.

28. (610) Allotter B in an XY linefinder-allotter (FO 1) provides for the distribution of calls from odd-numbered line circuits

    a. if allotter A encounters two faulty linefinders in succession.
    b. as long as it is in an operating condition.
    c. when an all-trunks-busy condition exists.
    d. if relay TF in allotter A operates.

29. (610) Circuits in an XY linefinder-allotter (FO 1) provide that when lines have been transferred from allotter A to the control of allotter B and two faulty linefinders are encountered in succession,

a. the lines would be transferred back to allotter A.
b. further transfer to other allotters will take place.
c. allotter A will start stepping and connect an alarm circuit.
d. allotter B will continue in control until an operative idle linefinder is found.

30. (610) Refer to foldout 1. An allotter that has been transferred may be put back into service by manually operating the appropriate

a. test switch.
b. rotary switch.
c. busy and reset switch.
d. monitor switch.

31. (611) What listed relay in the allotter (FO 1) if it fails, will not set up an allotter transfer?

a. FB.
b. SA.
c. AS.
d. PA.

32. (612) A visual check of the linefinder-allotter equipment shows relay FB in allotter A to be restored, although allotter B is operating satisfactorily. An analysis of the circuit in the schematic (FO 1) reveals that the equipment fault could be that

a. the busy switch has been operated accidentally.
b. contacts 11 and 12 of relay ST are separated by dirt.
c. the jumper between terminal 2 of circuit plate jack A and relay FB is open.
d. the ground connection to terminal 15 of shelf plug A has been disconnected.

33. (612) What is the trouble in the allotter (FO 1) when the line circuits operate and the linefinders overstep in the Y direction?

a. The ac winding of relay XS is open.
b. The ac winding of relay PA is open.
c. Contacts 22 and 23 of relay XS are dirty.
d. Contacts 5 and 6 of relay GD are dirty.

34. (612) What is the trouble when the linefinder (FO 1) is seized prior to full release of the switch?

a. X-ON contacts 5 and 6 do not make.
b. Y-ON contacts 5 and 6 do not make.
c. Z spring contacts 4 and 5 do not make.
d. Z spring contacts 1 and 2 are shorted.

35. (613) What is the hunting speed of an XY selector switch?

a. 30 steps per second.
b. 35 steps per second.
c. 40 steps per second.
d. 45 steps per second.

36. (613) A single selector switch may be used to connect

a. both outgoing trunks and subscribers lines.
b. incoming trunks and subscribers lines.
c. outgoing trunks and special services.
d. either outgoing or incoming trunks.

37. (614) Successful operation of an XY selector requires

a. absence of ground searching.
b. dialing 2 digits to the selector.
c. dialing for Y-direction stepping.
d. no dial tone for X-direction stepping.

38. (614) In an XY system, selector relay HA (FO 2) operates

a. before relay XD releases.
b. because of the closed Y interrupter contacts.
c. after relay XD releases but before the Y interrupter contacts close.
d. to open the Y interrupter contacts and close the Y off-normal contacts.

39. (614) Operation of the XY system selector relay SW (FO 2)

a. releases the selector.
b. closes the circuit of the Z magnet.
c. connects R3 in series with the MON lamp.
d. opens the T and R leads of the preceding equipment.

40. (615) Refer to foldout 2. When the XY switch is used as a selector, the circuit for X off-normal spring contact 7 is

a. omitted from the XY switch assembly.
b. not connected beyond the switch jack.
c. in series with the Y off-normal contact 7.
d. connected through terminal 20 of the shelf plug.

41. (615) Contacts 1 and 2 of an operated CB relay in an XY selector (FO 2) close

a. a partial path for relay SW.
b. a partial path for relay XD.
c. the operated path of relay RD.
d. the path through the monitor lamp.

42. (616) X-direction stepping of an XY system selector (FO 2) results from the interaction of relay CB,

a. relay XD, and relay HA.
b. relay RD, and relay SW.
c. the Y magnet, and the X magnet.
d. the X magnet, and the dial pulse springs.

43. (616) What relay action in an XY selector (FO 2) transfers X stepping to Y stepping?

a. HA relay operating.
b. XD relay releasing.
c. RD relay operating.
d. RD relay releasing.

44. (617) Y-direction stepping of an XY selector (FO 2) results from the interaction of relay HA and

a. relay SW.
b. the X magnet.
c. the Y magnet.
d. the dial pulse springs.

45. (617) Relay HA assists the XY selector switch (FO 2) when it is

a. stepping in the X direction.
b. stepping in the Y direction.
c. releasing from position Y-11.
d. stepping in the X and Y directions.

46. (618) When an XY selector (FO 2) encounters an all-trunks-busy condition,

a. the connector sends back a busy tone.
b. the switch stepped to the X-11 position.
c. the switch stepped to the Y-11 position.
d. busy tone is connected to the supervisory equipment.

47. (618) When an XY selector (FO 2) is stepped to the Y-11 position,

a. busy tone is sent to the called party.
b. dial tone is sent to the called station.
c. dial tone is heard at the calling station.
d. busy tone is heard at the calling station.

48. (618) While an XY system selector (FO 2) is returning to normal, ground is extended to the preceding equipment over the

a. HS lead.
b. S lead.
c. GBT lead.
d. MSR lead.

49. (619) Switchthrough is completed when the succeeding equipment (FO 2) is seized and

a. the Z magnet is operated.
b. the called station answers.
c. selector relay RD has released.
d. selector relay SW has released.

50. (619) Which of the following relays remain(s) operated in an XY selector (FO 2) after switchthrough?

a. CB.
b. SW.
c. RD and SW.
d. CB and SW.

51. (620) Refer to text figure 2-8. What action initiates the release of an XY selector switch?

a. Loss of ground at the S wiper.
b. Loss of ground at the T wiper.
c. Battery on the S wiper.
d. Battery on the T wiper.

52. (620) Refer to foldout 2. An XY system selector will release when selector

a. CB relay releases.
b. relay SW operates.
c. relay SW releases.
d. Y magnet operates.

53. (621) Refer to foldout 2. F wiring to an XY system selector restricts the use of lines or trunks by

a. a shunt across relay HA.
b. an XX bank connection to ground.
c. an HS lead connection to the X wiper.
d. a ground on the S wiper from the X bank contact.

54. (621) Spark protection for contacts 3 and 4 of relay HA (FO 2) is furnished by capacitor

a. C2 and resistor R1.
b. C1 and resitor R1.
c. C1 and resistor R2.
d. C2 and resistor R2.

55. (622) Refer to foldout 2. What is the trouble when an XY selector stops on the first trunk, idle or busy?

a. Open S wiper lead.
b. Open R wiper lead.
c. Open T wiper lead.
d. Contact 4 of relay SW is grounded.

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56. (622) Refer to foldout 2. What is the trouble when an XY selector will not step Y after stepping X?

a. XD relay released.
b. Y interrupter contacts are made.
c. Contacts 5 and 6 of relay HA do not make.
d. Contacts 1 and 2 of relay RD are shorted.

57. (623) The trunk-hunting feature of an XY connector is obtained by strapping the S and

a. T lead of each line, except the last.
b. HS lead of each line, except the last.
c. T lead of each line, including the last.
d. HS lead of each line, including the last.

58. (623) The PX connector is similar to a first selector in that it

a. hunts in the Y direction automatically.
b. sends dial tone to the calling party.
c. sends dial tone to the called party.
d. is shared equipment.

59. (624) The PX connector (FO 3) is seized when relay

a. SW in the linefinder operates.
b. ST in the selector releases.
c. SW in the selector releases.
d. ST in the linefinder operates.

60. (624) Which of the following is not a function of the XY PX connector (FO 3) during seizure?

a. Complete the hold path for relay BT.
b. Supply ground to the start (ST) lead.
c. Complete the operating path of relay XD.
d. Send ground back to hold preceeding equipment operated.

61. (624) The XY system PX connector relays (FO 3), listed in the order in which they operate during equipment seizure, are

a. ST, CB, RT, and XD.
b. RT, CB, ST, and XD.
c. CB, RD, RT, and XD.
d. XD, RT, ST, and CB.

62. (625) Relay CB in an XY system PX connector (FO 3) responds to dial pulses

a. during X-direction stepping and then during Y-direction stepping.
b. during Y-direction stepping and then during X-direction stepping.
c. after the XY switch steps in the Y direction.
d. while the Z magnet is operating.

63. (625) In an XY system PX connector circuit (FO 3), relay RT

a. releases when relay XD releases.
b. connects dial tone to the connector circuit.
c. releases when the called station is answered.
d. closes the circuits to the X magnet during Y-direction stepping.

64. (626) Before an XY system PX connector (FO 3) steps in the Y direction,

    a. the pulse springs must be closed.
    b. relays CB, RD, and XD must release.
    c. relay RD is operated by the dial pulse contacts.
    d. relay CB is held operated by the dial pulse contacts.

65. (626) Refer to foldout 3. Which choice is correct concerning an XY system connector?

    a. XD restores after each step in the Y direction.
    b. CB restores after the X-direction stepping is completed.
    c. BT operates before relay XD is released if the called station is busy.
    d. SW operates during the time lapse between the first and second steps in the X direction.

66. (628) When the operating circuit of relay SW is completed by two XY system connectors at the same instant,

    a. no switchthrough occurs.
    b. both connectors will switch through.
    c. the odd-numbered connector is rejected.
    d. the even-numbered connector is rejected.

67. (628) Ringback tone to the calling station from the XY system PX connector (FO 3) passes through

    a. C4 and contacts 5 and 6 of relay SW.
    b. C1 and contacts 9 and 10 of relay RT.
    c. C2 and contacts 1 and 2 of relay CB.
    d. C3 and contacts 25 and 26 of relay RT.

68. (628) Which choice gives the best description of a circuit condition that applies to relay RT in an XY PX connector (FO 3)?

    a. Operates on ringing current.
    b. Will operate on either AC or DC.
    c. Operates during the ringing interval.
    d. Has ringing current through its ca winding.

69. (628) The X contacts of relay RT in the XY PX connector (FO 3) operate

    a. prior to the other RT contacts to complete a locking circuit.
    b. slowly, thus delaying supervisory equipment disconnection.
    c. last, thus interrupting ringback and dial tones.
    d. during the ringing intervals.

70. (628) Refer to foldout 3. Which of the following is a correct description of the function of one circuit in the XY PX connector?

    a. Furnishes transmission battery to the calling station through capacitor C1.
    b. Furnishes transmission battery to the calling station through relay CB.
    c. Provides transmission battery to the called station through relay CB.
    d. Provides ringing current to the called station through C1 and C2.

71. (629) At the completion of a call in an XY system PX connector, if only one station disconnects immediately, connector relay RT (FO 3) is

    a. shunted by the Z magnet.
    b. released by contacts 8-7 of relay AB.
    c. released by contacts 7-6 of relay RD.
    d. held operated until the other station disconnects.

72. (629) The Z magnet in an XY system PX connector circuit (FO 3) operates

a. to start X-direction stepping.
b. to start Y-direction stepping.
c. when ground is removed from the S lead.
d. when relay XD opens its 1 and 2 contacts.

73. (629) Which of the following is the best description of operating conditions for relay SW (FO 3) in an XY system PX connector?

a. Releases when the called and calling parties hang up.
b. Is held operated by contacts 1 and 2 of restored relay AB.
c. Is held operated by contacts 5 and 6 of operated relay BT.
d. Releases when relay RT restores to open its contacts 21 and 22.

74. (630) Connector relay BT (FO 3) failes to operate when the S wiper contacts the S bank wire of a busy line in an XY system. Which choice presents the probable cause?

a. Dirty contacts 3 and 4 of selector relay RD.
b. Contacts 23 and 24 of connector relay XD are open.
c. Dirty contacts 21 and 22 of the operated line circuit relay CO.
d. Contract 22 of connector relay SW is shorted to contact 23 of relay SW.

75. (630) Refer to foldout 3. The called party answers a call and can hear but not be heard. Which choice presents the probable cause?

a. Dirty contacts 30 and 31 of the operated SW relay.
b. Dirty contacts 12 and 13 of the operated SW relay.
c. Shorted contacts 2 and 4 of operated AB relay.
d. Capacitor C2 open.

76. (630) Refer to foldout 3. What is the trouble when the calling party, after hearing no ringback tone, hears the called party answer?

a. Shorted contacts 5 and 6 of relay SW.
b. Shorted contacts 9 and 10 of relay SW.
c. Dirty contacts 5 and 6 of relay SW.
d. Dirty contacts 3 and 4 of relay SW.

77. (631) The group supervisory panel is located

a. on the relay rack.
b. on the powerboard.
c. in the switchboard.
d. in the last position of the shelf.

78. (631) What is the color of the visual alarm for a blown heat coil?

a. Red.
b. Blue.
c. Clear.
d. Green.

79. (632) Which listed common equipment is under control of the common supervisory circuit?

a. Linefinder and dual allotter.
b. Selectors and second selectors.
c. Trunks and auxilliary circuits.
d. Interrupter and ringing equipment.

80. (633) The normally operated relay in the common supervisory circuit (FO 4) is

a. ST 1.
b. CHG.
c. LA.
d. LV.

81. (633) Refer to foldout 4. How may the LV relay be made to release correctly?

a. By adjusting R1.
b. By adjusting R5.
c. By adding contact pressure.
d. By adjusting residual gap.

82. (633) The purpose of the LV alarm is to indicate

a. exchange battery voltage under 45.5 volts.
b. exchange battery charger under 45 volts.
c. linefinder voltage under 45.5 volts.
d. line voltage under 45 volts.

83. (633) The relays that operate in the common supervisory circuit (FO 4) when a delayed alarm is in progress are

a. SA, SB, and SC.
b. VA, VB, and LV.
c. E, F, and EF.
d. DA, DB, and DC.

84. (633) Which of the following failure alarms is delayed?

a. Individual fuse.
b. Equipment fuse.
c. Low voltage.
d. Emergency start fail.

85. (634) The nonemergency extension lamp in the common supervisory circuit (FO 4) never indicates an alarm. The first thing to check is

a. the lamp.
b. contacts 6 and 7 of relay E.
c. contacts 3 and 4 of relay EF.
d. the wiring between figures 1 and 2.

86. (634) On an emergency start fail alarm, relay SB (FO 4) fails to operate. The cause could be contacts

a. 3 and 5 of SB open.
b. 1 and 2 of SA open.
c. 3 and 4 of SB open.
d. 3 and 4 of SC open.

87. (635) Select two pieces of equipment which may generate ringing current.

a. Subcycle and DC ringing machine.
b. AC and DC interrupter.
c. Tone generator 1 and 2.
d. Charger 1 and 2.

88. (635) Refer to foldout 7. What type of subcycle is used in XY offices?

a. AC.
b. DC.
c. AC and DC.
d. Dynamotor.

89. (636) The voltmeter (figure 3 of foldout 6) of the discharge and distribution circuit indicates

a. charge voltage.
b. discharge voltage.
c. exchange voltage.
d. low-voltage alarm.

90. (636) Refer to foldout 6, figure 3. In what manner is the ammeter on the discharge and distribution circuit connected with equipment circuit breakers and the negative main battery?

a. Series parallel.
b. Parallel.
c. Multiple.
d. Series.

91. (636) The purpose of the RF-1 and RF-2 (FO 7) is to

a. prevent chattering of G1 and G2.
b. bypass every other cycle of AC.
c. make G1 and G2 release on time.
d. reduce voltage.

92. (637) Refer to foldout 8. The DC interrupter will not start. The first place to check is

a. the 48V supply.
b. the 110V AC supply.
c. contacts 25 and 26 of relay F.
d. the INT ST2 lead to figure 1.

93. (638) Which choice is correct concerning the function(s) of the XY fire alarm trunk circuit?

a. The fire alarm trunk circuit is mounted on the switchboard.
b. The fire alarm circuit signals the fire department only.
c. All calls must be handled by the switchboard operator.
d. All fire calls can be monitored by the operator.

94. (638) The inspector's ringback circuit is accessed from the

a. special second selectors.
b. second selectors.
c. first selectors.
d. connectors.

95. (639) In an XY system, the relay in the fire repeater (FO 9) that extends ringing current to the fire department is the

a. F relay.
b. RT relay.
c. FA relay.
d. RD relay.

96. (639) When the "C" wiring option is used in the XY fire repeater (FO 9), what circuit action is responsible for alerting the switchboard operator of a fire call?

a. Relay FA operates.
b. Relay RD operates.
c. Relay RT releases.
d. Relay CB releases.

97. (639) In an XY fire repeater (FO 9), relay RT (ring trip) does which of the following?

a. Signals the switchboard operator.
b. Operates the signal bell in the exchange.
c. Close contacts 21-23 to operate relay CB.
d. Cuts off ring current to the fire department.

98. (640) What relays are operated in the local trunk (FO 10) when it is seized from the local attendant's cabinet?

a. PL, SW, SR2.
b. CB, RD1, RD11.
c. CB, RD1, PL, SW.
d. PL, SW, SR2, CB, RD1.

99. (640) After switchthrough to a dial-to-dial trunk (FO 10), the preceding switch releases. The probable cause would be

a. punching A-6 and A-11 shorted.
b. contacts 5 and 6 of SW not making.
c. contacts 1 and 2 of RD1 not making.
d. lead on punching A5 is broken off.

100. (640) Seizing the two-way dial trunk circuit (FO 10) through a selector, the following relays will operate in the distant office:

a. CB, RD1, RD11, and SR1.
b. CB, RD1, and RD11.
c. PL, SW, and SR2.
d. PL and SW.

101. (640) During seizure of the distant office two-way dial-to-dial trunk (FO 10), the SW relay does not operate. Which of the following could be the possible cause?

a. Contacts 4 and 5 of PL dirty.
b. Contacts 3 and 4 of PL dirty.
c. Contacts 24 and 23 of SW dirty.
d. Contacts 22 and 23 of test jack dirty.

102. (640) In the two-way dial trunk circuit (FO 10) after the called party answers, the first relay to operate in the distant office is

a. SR1.
b. SR2.
c. SR11.
d. RS.

103. (640) The calling subscriber dials through the dial-to-dial trunk (FO 10) to the distant office; when the called party answers, no conversation can take place. One probable cause in the local trunk circuit would be faulty contacts

a. 1 and 2 of SR11.
b. 1 and 2 of SR1.
c. 4 and 6 of SR11.
d. 3 and 4 of SH2.

104. (640) On an outgoing call through the two-way trunk circuit (FO 10), the relays that are operated during conversation in the distant exchange are

a. CB, SR2.
b. PL, SW.
c. PL, SW, SR2.
d. CB, RD1, RD11.

105. (640) Which listed relay is the first to release in the two-way dial trunk circuit (FO 10) when the called party hangs up first?

a. CB.
b. PL.
c. SW.
d. SR2.

106. (641) What relay operates in the ringback circuit (FO 11) after the installer hangs up the first time?

a. RD.
b. SW.
c. RT.
d. CB.

107. (641) What causes the reversal of ringing in the ringback circuit (FO 11) from the tip side of the line to the ring side?

a. Relay RV operating.
b. Relay RV releasing.
c. Ground on the REV G lead.
d. Use of the "W" wiring option.

108. (641) Which set of contacts listed below is not part of the initial operate path of relay RT in the ringback circuit (FO 11)?

a. 1 and 2 of RD.
b. 5 and 6 of RV.
c. 6 and 7 of SW.
d. 5 and 6 of RT.

109. (642) The relays that are operated in the information or operator's trunk circuit (FO 13) during conversation are

a. CB, RD, SL.
b. RD, SL, SL1.
c. CB, RD, SL1.
d. CB, RD, SL, SL1.

110. (643) The operator can not transmit or receive on any of the cord circuits (FO 12). The probable trouble would be

a. contacts 8 and 9 of OC do not make.
b. contacts 21 and 22 of OT shorted.
c. contacts 13 and 14 of OC do not make.
d. contacts 1B and 2B of the MON key shorted.

111. (643) When the operator plugs a call cord (FO 12) into an out-dial-to-connector line jack, the operate path for relay FB is through

a. diode A.
b. diode B.
c. contacts 5 and 6 relay FLS.
d. contacts 2 and 3 of relay FLS.

112. (643) When connected to an out-dial-to-connector trunk, what indication does the operator get when the called party answers (FO 12)?

a. Busy lamp lights.
b. Supervisory lamp lights.
c. Line lamp is extinguished.
d. Supervisory lamp is extinguished.

113. (643) The hold path for relay OC in the cord circuit (FO 12) is through contacts

a. 1D and 2D of the TALK key.
b. 1C and 2C of the TALK key.
c. 3 and 4 of the OC relay.
d. 3 and 4 of the MR relay.

114. (644) Refer to foldout 14. The initial operate path for relay LR in the XY convertible line circuit when used as an LB line circuit is through contacts

a. 7 and 8 of relay LR.
b. 3 and 4 of relay CO.
c. 1 and 2 of relay LR.
d. 4 and 5 of relay CO.

115. (644) What relay provides supervision on a local battery call (FO 12)?

a. CO.
b. OC.
c. RB.
d. RLS.

116. (645) If contacts 1 and 2 of RT relay in the inspector's ringback circuit (FO 11) did not make, what effect would it have on the circuit?

a. No ground on the sleeve to keep the circuit from being seized by two parties.
b. The repairman would be unable to release the circuit.
c. No ringback tone when the repairman hangs up.
d. Ringing on one side of the line only.

117. (645) Neither busy lamp nor incoming line lamp (FO 14) illuminates on an incoming call from an LB subscriber. The probable cause for this malfunction is dirty contacts

a. 3 and 4 of LR.
b. 5 and 6 of LR.
c. 1 and 2 of LR.
d. 4 and 5 of CO.

118. (645) The operator (FO 12) receives ring-off supervision only as long as the hand generator is turning. The cause is

a. supervisory lamp burned out.
b. contacts 2 and 3 of RB dirty.
c. contacts 1 and 2 of RHS dirty.
d. contacts 7 and 8 of RLS dirty.

119. (646) Which lamps on the XY switch test set have green colored jewels?

a. Speed.
b. Release.
c. Overflow.
d. Off-Normal.

120. (646) Which listed test set(s) can be used to perform an operational check of the pulsing circuits of XY selector and connector equipment?

a. Test handset.
b. Pulsing limits test set.
c. Circuit plate maintenance test set.
d. All of the above.

121. (646) What will be the effect on the current of a switching center pulsing relay circuit when the pulsing limits test set SHUNT switch is operated?

a. DC current increases.
b. AC durrent increases.
c. DC current decreases.
d. AC current changes intermittently.

122. (647) Using figures 6-6 and 6-7, determine the next switch in the switch train if the calling party's number is found in switch 13.

a. Selector switch 19.
b. Selector switch 20.
c. Connector switch 13.
d. Connector switch 14.

123. (647) Refer to figures 6-8 and 6-9 of the text. Selector 5 is stepped X-2 and Y-3. If you are tracing a call from the called number, what is the next switch in line?

a. Linefinder 4 on shelf C.
b. Linefinder 7 on shelf A.
c. Connector 7 in C-1-B.
d. Connector 1 in C-1-B.

124. (647) Refer to figures 6-8 and 6-9 of the text. Selector 5 is stepped X-2 and Y-3. What is the next switch in line when tracing from the calling number?

a. Linefinder 4 on shelf C.
b. Linefinder 7 on shelf A.
c. Connector 7 in C-1-B.
d. Connector 1 in C-1-B.

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CDC 36251

TELEPHONE SWITCHING EQUIPMENT REPAIRMAN (ELECTROMECHANICAL)

(AFSC 36251)

Volume 5

AUTOVON Interface Equipment and Base Wire System

Extension Course Institute

Air University

Preface

WITH THE inclusion of the AUTOVON into the Air Force inventory, worldwide direct distance dialing became a reality. In order for this to become a reality, two things were necessary—equipment to interface our two-wire system to the four-wire system and cable that would handle it.

In this volume some of the interface circuitry is discussed with respect to circuit operation and maintenance and the testing and maintenance of the base cable plant to handle AUTOVON and other quality circuits.

There are 10 schematic foldouts included with this volume. These foldouts are printed and bound as a separate inclosure.

If you have questions on the accuracy or currency of the subject matter of this text, or recommendations for its improvement, send them to SAAS/TTOXU, Sheppard AFB TX 76311. NOTE: Do not use the suggestion program to submit corrections for typographical or other errors.

If you have questions on course enrollment or administration, or on any of ECI's instructional aids (Your Key to Career Development, Behavioral Objective Exercises, Volume Review Exercise, and Course Examination), consult your education officer, training officer, or NCO, as appropriate. If he can't answer your questions, send them to ECI, Gunter AFS AL 36118, preferably on ECI Form 17, Student Request for Assistance.

This volume is valued at 30 hours (10 points).

Material in this volume is technically accurate, adequate, and current as of December 1978.

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CHAPTER 1

NOTE: In this volume, the subject matter is developed by a series of Learning Objectives. Each of these carries a 3-digit number and is in boldface type. Each sets a learning goal for you. The text that follows the objectives gives you the information you need to reach that goal. The exercises following the information give you a check on your achievement. When you complete them, see if your answers match those in the back of this volume. If your response to an exercise is incorrect, review the objective and its text.

AUTOVON Interface Equipment and Trunk Circuits

YOU HAVE PROBABLY placed a long distance call within the United States by direct dialing through a commercial telephone system. This is a fast, easy way to communicate. The Department of Defense (DOD) and other Government users have a worldwide communications network in which a subscriber can obtain an interconnection with any other subscriber within 10 seconds. This worldwide communications system is known as the *AUTO*matic *VO*ice *N*etwork (AUTOVON). The network is divided into two parts: (1) the *con*tinental *U*nited *S*tates *AUTO*matic *VO*ice *N*etwork (CONUS AUTOVON) and (2) Overseas AUTOVON. CONUS AUTOVON includes all of the networks within the North American Continent, except Panama.

Present plans call for approximately 100 switching centers, 78 located in the United States, Canada, and Alaska, and 22 locations in oversea areas. Centers in the United States are owned and operated by commercial companies. The Government leases service on a line-by-line basis. The oversea portion of AUTOVON is generally Government-owned facilities.

The Defense Communication Agency (DCA) is responsible for overall policy and management of the program. DCA performs day-to-day management and supervision of the trunks between switches which are the backbone of the network. The military departments—Army, Navy, and Air Force—are responsible for all Government-owned plant and terminal facilities and for determining their requirements for AUTOVON services, including access and subscriber lines.

1-1. Interface Equipment Description

The portion of this system that you are most concerned with is the interface equipment between your central office and one of the AUTOVON switches (commonly referred to as the "switch"). It is however, necessary to know something about the whole system to properly maintain and troubleshoot the interface equipment.

800. Concerning the service available from AUTOVON, name and define the types and give the meaning of DTMF, the maximum number of precedence levels a four-wire subscriber may obtain, and the DSA operators' functions.

Services Available From AUTOVON. AUTOVON is intended to offer the following services to its worldwide users and subscribers:

(1) User (normal) service provides the capability for users to call other users on a worldwide basis. Two types of service are available. The first enables users to dial desired numbers and accomplish a direct connection. Second, particularly those through limited trunking facilities, will be placed through operators.

(2) Four-wire service subscribers are provided direct access to one or more AUTOVON switching centers. This equipment may be a single or multiline telephone instrument. Signaling from four-wire subscribers is on a dual tone multifrequency (DTMF) basis. DTMF is a signaling method employing set combinations of two specific frequencies. One frequency is selected from a group of four low frequencies and the other from a group of four high frequencies. Four-wire subscribers are provided with up to five levels of call precedence. Precedence is a rank assigned to indicate the degree of preference to be given in processing calls. A four-wire subscriber may employ any level of precedence desired, up to and including his highest authorized level.

(3) "Off-hook" services (hot lines) are provided through the AUTOVON. An "off-hook" subscriber, upon lifting the handset of his telephone, will immediately be connected through the network to a predesigned subscriber. A separate instrument (or one

that has a special circuit added to the instrument) is provided for each "off-hook" subscriber.

(4) Special-purpose operations are accommodated by AUTOVON. Category 1 allows subscribers to employ abbreviated keying to certain other designated subscribers. Their instruments also give normal AUTOVON four-wire service. Category 2 provides special treatment to subscribers within a community of interest over AUTOVON general-purpose facilities. All members of a community of interest are capable of exercising a level of precedence within their community, higher than that permitted them on the world AUTOVON.

(5) Conferences can be either random or preset. Random conferences, which can include any AUTOVON subscriber or user, may be established with precedence levels through a dial service assist (DSA) operator. Preset conferences may be established by keying specified digits.

(6) DSA operators are provided at selected AUTOVON locations. These operators provide information assistance, establish conferences, and place precedence calls for AUTOVON users who cannot place such calls directly. They also provide manual service through facilities such as high-frequency radio links where the quality is not considered adequate for automatic switching.

Exercises (800):

1. Name and define the two types of service available to the AUTOVON subscriber.

2. What do the letters DTMF stand for?

3. What is the maximum number of precedence levels that a four-wire telephone subscriber may be provided?

4. What are the functions of the DSA operators?

801. Give the purpose and functions of selected AUTOVON transmission and terminal facilities, networks, four-wire instruments, and major interface equipment components.

Transmission and Terminal Facilities. Because of the long distances spanned by AUTOVON—12,000 to 15,000 miles—transmission facilities must conform to the highest technical standards. AUTOVON is designed for interconnection of up to seven voice grade trunks in tandem; therefore, network transmission facilities are four-wire except at PBXs (private branch exchanges) where two-wire connections to station equipment is normally used. Up to four data (teletype, etc.) grade trunks may be connected in tandem.

Terminal facilities in AUTOVON consist of direct four-wire telephone instruments for certain users, special consoles for command and control users such as NORAD (North American Air Defense Command) and PBXs which serve the great majority of users. When connections between PBXs and the AUTOVON switches are made, interface equipment must be installed in the PBX.

Networks. AUTOVON subscribers and users have access to subscribers served by other switching centers. These connections are established over the trunks between the various switching systems. A routing digit, provided in the numbering plan, is used to process calls through the network and will permit automatic crossover between networks. A network consists of the AUTOVON switching centers, the trunks connecting one AUTOVON switch to another, and the trunks connecting central offices (PBXs) to an AUTOVON switch; all within one geographic location; for example, Europe, Pacific, or CONUS.

Four-Wire Instruments. Many different types of subscriber equipment may be used at AUTOVON stations, but we will discuss only the basic four-wire instrument (telephone), shown by figure 1-1. The basic instrument includes a telephone handset, DTMF key pulsing equipment with 15 or 16 keys, a hook switch, a tone ringer, and circuitry necessary to perform the required functions. In figure 1-2, look at the block labeled "Keyset and Oscillator." Each four-wire instrument has a built-in DTMF oscillator.

The DTMF oscillator provides a group of four *low* frequencies and a GROUP of four *high* frequencies for signaling; see figure 1-3. The low frequencies are 697, 770, 852, and 941 Hz. The high frequencies are 1,209, 1,336, 1,477, and 1,633; note that each digit is represented by a tone-pair; this makes for faster keying (dialing). It takes no longer to signal the digit 9

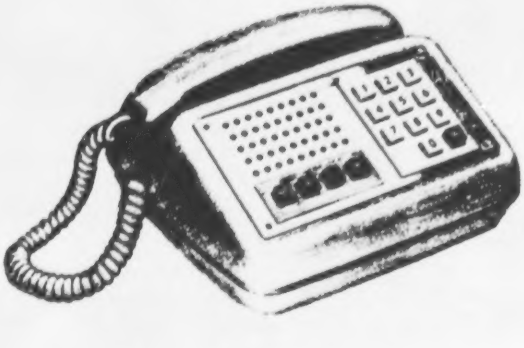

Figure 1-1. Four-wire instrument.

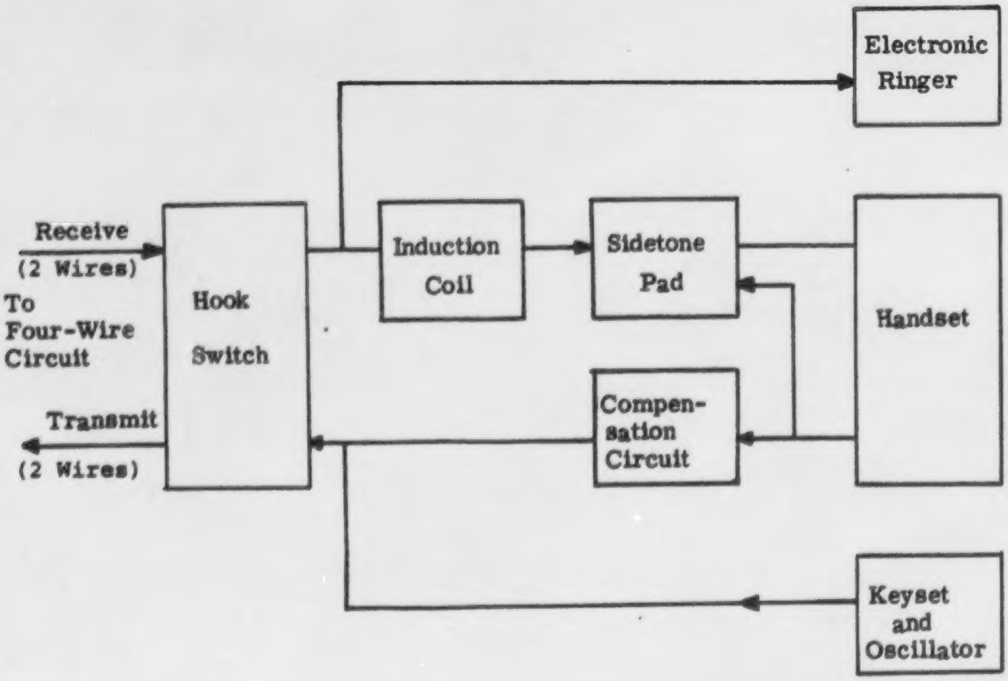

Figure 1-2. Four-wire subset, functional block diagram.

than it does the digit 1 when two tones are used for each digit.

Look again at the keys shown in figure 1-1; the *A key* is used to indicate "end of address" when an abbreviated address (number) is keyed. *FO, F, I, and P keys* are used to indicate the precedence of the originating call. The precedence keys may be arranged either in a horizontal or in a vertical group. The order from left to right (or top to bottom) is FO, F, I, and P.

Precedence levels, designated zero through four, are required with service preference according to rank. Precedence level four is used for normal routine calls. Precedence level zero is the highest ranking precedence:

Precedence Levels

Number	*Precedence Level*
0	Flash override
1	Flash
2	Immediate
3	Priority
4	Routine

Each four-wire subscriber may use any precedence up to, and including, the highest authorized for him. The precedence level of a call is normally determined by the caller. If a subscriber attempts a higher precedence than that to which he is authorized, the call is routed to a recorded announcement.

Major Interface Equipment Components. Since all AUTOVON access lines are four-wire, two-wire users may be connected into AUTOVON only as a part of another system, such as a PBX. By using a four-wire transmission path, we separate our transmitting from *their* transmitting (*our* receiving). This gives us less noise and echo, as losses can be inserted into the line to compensate and allow for one-way amplification. In order to "interface" (interconnect) the two-wire PBX with the four-wire 490L AUTOVON switching center, a rack of interface equipment is installed in the PBX.

The equipment is rack mounted; but the physical location and arrangement of the equipment may vary from one central office to another.

Each trunk requires a two-wire/four-wire trunk circuit; i.e., an SF (single frequency) signaling set which converts pulse signals in the two-wire system (your central office) to tone signals in the four-wire system and vice versa. A telephone repeater which consists of a voice-frequency line amplifier and a terminating unit (hybrid coil) is also necessary for each trunk. The telephone repeater amplifies voice signals to the desired level (specified by DCA) for proper transmission and matches terminating impedances of the two-wire/four-wire lines. It is normally mounted beside the SF unit for the same circuit.

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Four-Wire Subset Oscillator Tone Pairs

PUSHBUTTON KEY	TONE PAIRS (HZ)
ADDRESS KEYSET	
1	697 + 1209
2	697 + 1336
3	697 + 1477
4	770 + 1209
5	770 + 1336
6	770 + 1477
7	852 + 1209
8	852 + 1336
9	852 + 1477
0	941 + 1336
A	941 + 1477
(Not Used)	941 + 1209
PRIORITY KEYSET	
FO	697 + 1633
F	770 + 1633
I	852 + 1633
P	941 + 1633

HC-049

Figure 1-3. Four-wire subset oscillator tone pairs.

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There is also a switchboard applique circuit which converts address signals used in the local exchange to loop pulsing needed by the two-wire/four-wire trunk circuit (often referred to as the trunk or interface trunk). A precise tone supply circuit is provided to work in conjunction with the switchboard applique circuit. It generates the signaling tones that permit the operator to dial precedence calls.

About all that is left is the test circuits, of which there are three: (1) the noise and balance test line, (2) the loop around test line, and (3) the reverse battery test line. These circuits permit AUTOVON switch personnel to test selected functions of the interface without the help of your people.

Exercises (801):

1. What is the maximum number of voice grade circuits, interconnected in tandem, the AUTOVON system is designed for?

2. What does an AUTOVON network consist of?

3. What is the purpose of the FO, F, I, and P keys on the four-wire instrument?

4. What happens if a four-wire subscriber attempts to use a precedence level higher than he is authorized?

802. Identify and relate the purpose or function of selected AUTOVON interface equipment and equipment configuration and operation.

Equipment Configuration. Foldout 1 (in separate inclosure) shows how the major components of the interface equipment tie the local exchange equipment to the AUTOVON system. Local subscribers can access the interface trunk circuit from the banks of through or local first selectors and from the attendant's cabinet for outgoing calls. On incoming calls, the calling party can call into the attendant's cabinet for operator assistance or he can dial the number of the local subscriber through the incoming selector and connector.

While Strowger and XY trunk circuits use two-wire trunks for dialing, transmitting and receiving, and supervision between offices, AUTOVON uses a four-wire trunk between offices. From the interface trunk circuit we have a two-wire connection to the two-wire/four-wire terminating unit (hybrid) that is used for our transmission path. We also have a two-wire connection to the SF signaling set; these wires are our E and M leads and are used for addressing (dialing or tone) and for supervision.

When we speak of supervision, we are talking about whether the trunk is idle or in use.

You may have noticed that we have two wires between the trunk circuit and the hybrid and four wires from the hybrid throughout the rest of the circuit to the AUTOVON access; this is our transmission path.

Again, the physical interface equipment may be arranged differently in the central offices you are assigned to. Physical location of equipment or its arrangement normally depends upon the amount of equipment installed and its placement for ease in maintenance.

Trunk circuit. This circuit was designed for use as a two-wire interface between a PABX (private automatic branch exchange—a term used by the Automatic Electric Co.) and an AUTOVON switching center. The circuit provides a means of completing incoming and outgoing routine and precedence level calls.

Network inward dialing (NID) calls are established between the AUTOVON calling party and the PABX called party without the assistance of the PABX attendant. The incoming call is processed to the PABX called station through an incoming selector.

Network outward dialing (NOD) calls are established between the PABX calling party and the AUTOVON called party without the assistance of the PABX attendant. The outgoing call is processed to AUTOVON through a trunk from a first selector.

Precedence alerting and preempt signals from the distant AUTOVON switching center are detected by the two-wire/four-wire circuit, thus any call may be preempted. A precedence network inward dialed (PNID) call from AUTOVON to a PABX station that is busy or which does not answer within 12 seconds will be diverted to the attendant's cabinet. The precedence answer lamp will flash at 60 IPM, signaling the attendant that the call is an incoming priority diversion call. The PABX attendant can then preempt any routine call in the two-wire/four-wire circuit.

SF signaling unit. Single frequency signaling units are required with carrier, radio signaling, or over long wire loops. The SF signaling unit is a complete, self-contained 2,600-Hz in-band signaling system. The term in-band refers to the voice frequency band of 400 to 3,400 Hz.

One purpose of the 2,600-Hz tone is to mark the interoffice (between offices) trunks idle. The tone is a reliability factor. If at any time an idle trunk becomes disabled, the tone stops, bringing in an alarm, telling maintenance personnel there is a trouble.

The SF signaling unit is a compact key telephone unit (KTU) type module consisting of a voice-frequency oscillator drawer and control unit drawer, shown in figure 1-4. Test jacks on the front panel are

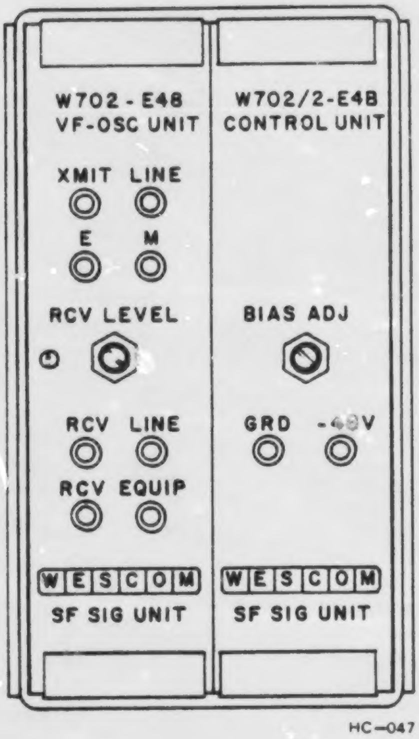

Figure 1-4. SF signaling unit.

provided for monitoring the operating signal and voltage levels.

Another purpose of the 2,600-Hz tone is to transmit supervision in both directions over the four-wire interoffice trunk facilities. Remember that the 2,600-Hz tone denotes an idle trunk.

With the local terminal in the idle (on-hook) condition, the M-lead is at ground potential and the tone oscillator in the SF signal unit places a 2,600-Hz tone on the *transmit line*, shown in figure 1-5. When the local terminal handset is lifted (off-hook), negative 48 volts is applied to the M-lead and the tone oscillator turns off, removing the idle line condition.

With the far terminal in the on-hook condition, the 2,600-Hz tone comes in on the *receive line* of the local terminal. Under this condition, the E-lead is open. With the far terminal in the off-hook condition, there is ground on the E-lead and no tone on the receive pair.

Supervision has two STATES—(1) "off-hook" and (2) "on-hook," both shown below:

State	*E-Lead (From SF Unit)*	*M-Lead (From 2-wire/ 4-wire Trunk)*
On-hook (Tone)	Open	Ground
Off-hook (No Tone)	Ground	-48 Volts

Both the off-hook and the on-hook signals are referred to as "supervision." They are the two supervisory signaling conditions of an interswitch trunk, a subscriber line, or a PBX access line.

Look at figure 1-5 and locate the four-wire terminal equipment. With the handset of the four-wire telephone in the cradle, the supervisory state is on-hook. The E-lead is open, and the M-lead is grounded; trace the leads on figure 1-5. In this condition, the SF unit sends a 2,600-Hz tone on the transmit pair to mark the trunk idle to the 490L switch.

When the handset of the four-wire telephone is lifted, the supervisory state is off-hook, and the M-lead potential is negative 48 volts. The SF signal unit now removes the 2,600-Hz tone from the transmit pair, which indicates to the AUTOVON switch a demand for service. Dial tone would then be sent to the subscriber.

On an incoming call (a distant off-hook condition) to the four-wire telephone, the E-lead will have a ground sent *from the SF signal* unit to the *line adapter*. This causes the line adapter to send a signal tone to the tone ringer in the four-wire telephone, which is in an on-hook condition.

Remember, the far end supervisory condition is reflected by the E-lead, while the near end supervisory condition is reflected by the M-lead.

Routine incoming calls to a PBX will use a normal on-hook seizure signal. Ringing signals to the PBX will be the normal PBX ringing when the connection is completed at the PBX.

Two varieties of signaling are used for transmitting address information to the AUTOVON switch. Thus, both four-wire subscribers and PBX attendants at precedence positions use DTMF signaling, whereas PBX users use dial pulsing. Examples of both types of addresses follow.

When the *four-wire subscriber* goes off-hook, a supervisory signal is sent to the switching equipment demanding service, as shown in figure 1-5. The hookswitch closes a circuit to the adapter circuit which replaces ground with negative 48 volts on the M-lead to the SF unit. The SF unit now removes the idle line 2,600-Hz tone from the transmit pair of the trunk. After dial tone is heard, addressing is accomplished by the operation of the DTMF keys. A common switch in the instrument disables the transmitter during the address-keying operation. Individual key contacts select the proper AC tone-pair corresponding to the digit key operated in the keyset. These distinct frequency combinations are sent over the transmission facilities to the switching

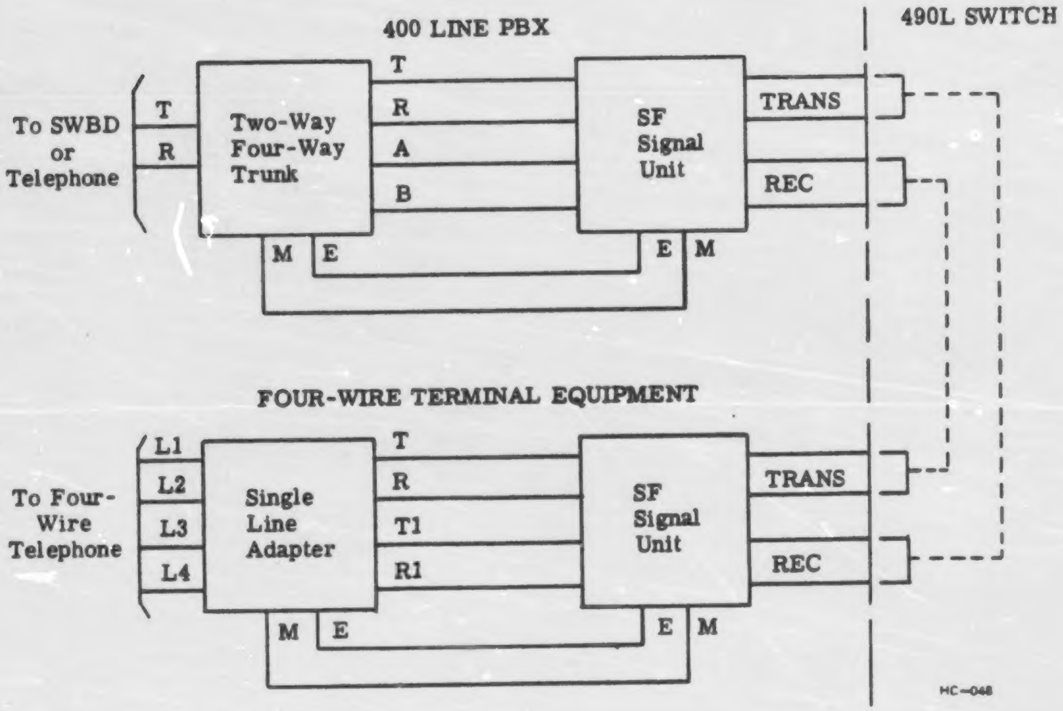

Figure 1-5. SF signaling unit and E- and M-leads.

center DTMF receiver for digital (numbers 0 to 9) recognition. The subscriber will hear the tone sent out by each key.

The *two-wire subscriber* goes off-hook closing a loop to a selector, receives dial tone, and then dials 8; refer to foldout 1 (found in a separate enclosure). After accessing the AUTOVON equipment, the subscriber dials the AUTOVON address. The dial opens and closes the loop to the two-wire/four-wire trunk, which applies and removes negative 48 volts on the M-lead, shown in figure 1-5. The SF signaling unit converts the DC signals received on the M-lead into 2,600 Hz tone-on/tone-off signals, shown in figure 1-6. The amplified tone bursts are sent to the switching equipment. Figure 1-6 shows that the digit 3 was dialed.

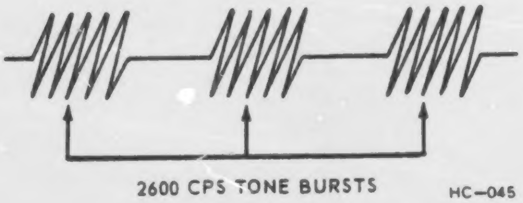

Figure 1-6. Dialed pulses from two-wire telephone.

When the two-wire subscriber receives a call, the SF signal unit receives 2,600-Hz tone-on/tone-off signals. These are converted to interrupted ground pulses on the E-lead.

E- and M-lead signaling may be summarized as an arrangement whereby communication between a trunk circuit and a separate unit is accomplished over two leads: The M-lead trans*M*its battery or ground signals to the signaling equipment, and an E-lead rec*E*ives open or ground signals from the signal unit.

Preemption is accomplished at the switching center by sending a measured supervisory signal pulse toward both the calling and called lines. The supervisory pulses are recognized at each switching center, causing disconnect of the intermediate trunk circuits and the line circuits at each end. Following circuit release, the preempt tone of 440 + 620 Hz from the precise tone supply is applied to each end-subscriber from the line or trunk circuits. The tone is maintained until a disconnect signal is returned to the switching center. The trunk or line which was selected for preemption is now reused to serve the waiting precedence call.

The recall signal is used to recall the DSA operator when an outgoing call has been placed through the DSA switchboard. The signal may be generated either of two ways: One four-wire subscriber or a PBX user may depress the hookswitch for 300-ms (millisecond) up to 2 seconds. The other, a PBX attendant may operate and release the cord ring key. The trunk circuit will send a 300-ms on-hook signal to AUTOVON after the key is released. AUTOVON converts the signal for retransmission to the DSA switchboard.

Telephone repeater. The repeater, shown in figure 1-7, consists of a plug-in amplifier drawer and a plug-in terminating set. The terminating set is a two-wire/four-wire terminating unit, while the amplifier portion is a voice-frequency line amplifier. This unit is used both for four-wire DTMF circuits and two-wire/four-wire trunk circuits. When used with four-wire instruments, the terminating unit is not required, and the space is covered with a blank panel.

The VF line amplifier rebuilds signal strength to insure proper transmit and receive levels on four-wire transmission facilities.

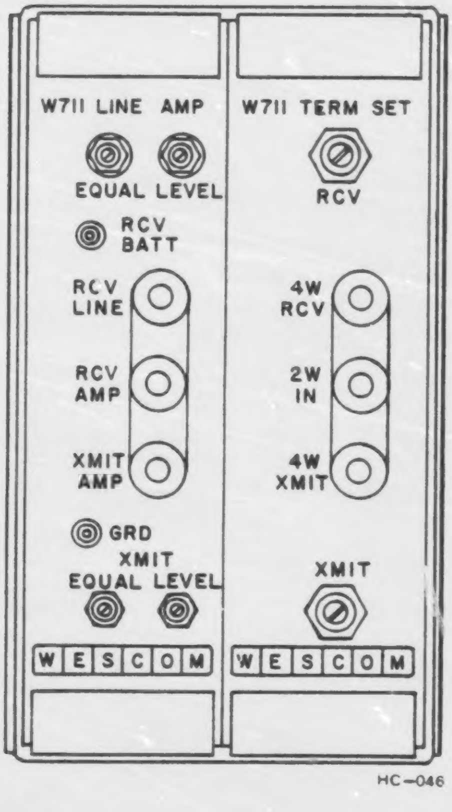

Figure 1-7. Telephone repeater.

The two-wire/four-wire terminating unit provides 600-ohm termination for the transmit and receive circuits of both the four-wire transmission path and two-wire transmission path. The terminating set contains adjustable hybrid balance and impedence compensation networks which provide proper balance and equalization of transmit and receive levels on the four-wire and two-wire circuit. The two-wire/four-wire terminating unit thus provides termination and impedence matching of the two-wire send-receive of the PBX and the four-wire transmission facility.

Foreign applique. There are various combinations of foreign applique assembiles that adapt the basic two-wire/four-wire trunk circuit to foreign equipment.

The purpose of these assemblies is to provide loop pulsing as required by the two-wire/four-wire trunk. The trunk then converts this pulsing to E and M signaling as required by AUTOVON switching equipment.

Test equipment. The reverse battery test line circuit, end office loop around test circuit, and noise and balance test line circuit, shown in foldout 1, provide termination at the PBX for making transmission tests on the trunks from AUTOVON. The AUTOVON switch can access and test the functions of the interface equipment without the assistance of the PBX maintenance personnel.

The test jack assembly, as foldout 1 shows, permits patching into the interface equipment, by the PBX attendant, for testing of the equipment or for rerouting around a piece of equipment which is malfunctioning.

Switchboard Applique The purpose of the applique is to modify the switchboard circuits so that they may be used with AUTOVON.

We now cover the changes required at a two-wire switchboard position to make it operational with AUTOVON. This includes switchboard trunk and lamp arrangements for PABX access lines and modifications for operation with a DTMF keyset.

Face equipment. The PABX subscriber has no means of generating precedence calls and must place all precedence calls through the PABX attendant. The lamp and jack arrangement used on the face of the switchboard determines the type of trunk circuit selected for the access line to AUTOVON. For instance, a two-wire switchboard trunk circuit without preemption features requires one jack and two lamps. A trunk circuit with preemption detection requires two jacks and four lamps, as shown in figure 1-8, reading down from the top.

DTMF keyset. The DTMF keyset, shown in fig. 1-9, is used to modify the position circuit of the attendant's cabinet for precedence calling. The tone pair frequencies transmitted for each pushbutton (key) operation are the same frequencies as those shown in figure 1-3.

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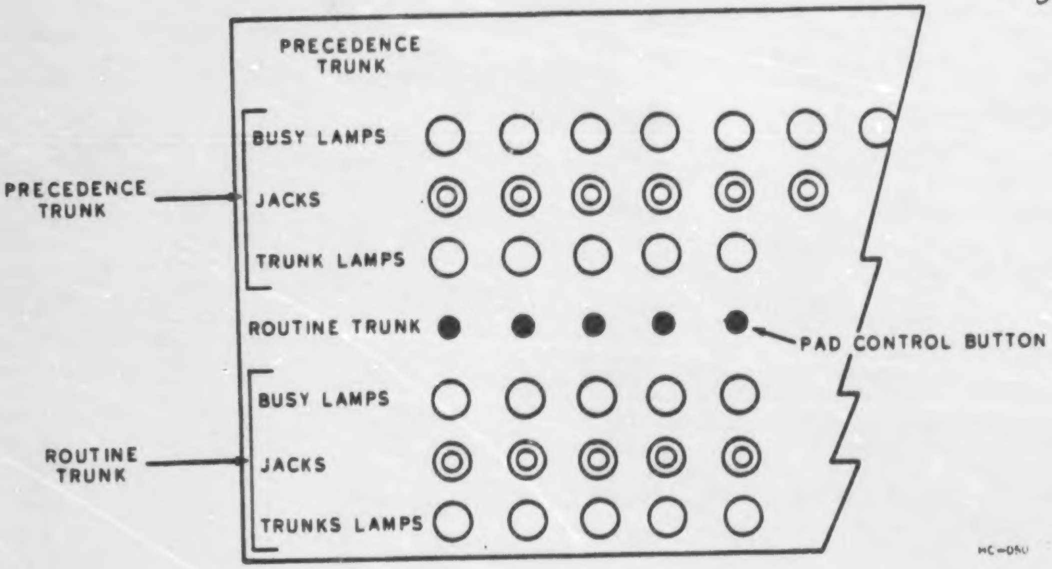

Figure 1-8. Face of PBX SWBD with preemption detection.

For ease of operation the DTMF keyset is normally installed in a convenient location on the switchboard keyshelf. The attendant may make an AUTOVON call by using the dial, but the keyset must be used if a precedence call is made. The modifications at the attendant's cabinet, the switchboard applique, and the two-wire/four-wire trunk make it possible for NID, NOD, PNID, and SWBD precedence outgoing calls to be made.

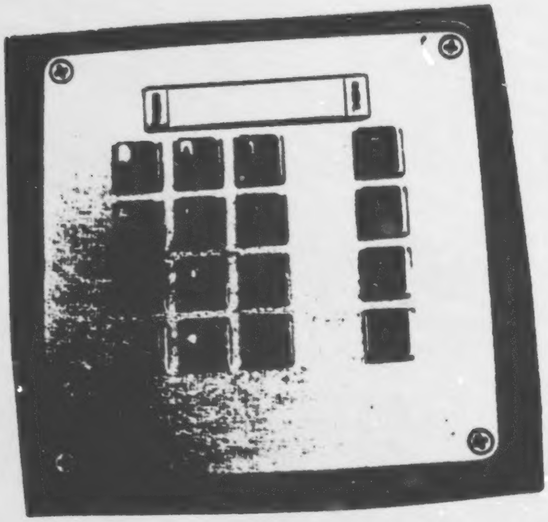

Figure 1-9. DTMF keyset.

Polarity reversal circuits. The polarity reversal circuit repeats the answer lamp and busy lamp control signals (AL and BL) from the trunk circuits to the lamps mounted in the attendant's switchboard multiple.

The polarity reversal contains two busy lamp auxiliary relays and two answer lamp auxiliary relays. Each auxiliary relay is wired to operate when ground is applied on the corresponding lamp control lead. Each auxiliary relay, when operated, applies ground or battery (as determined by optional wiring according to PABX design) to the lamp control leads serving lamps mounted in the PABX attendant's switchboard.

Exercises (802):

1. What determines the physical location of the interface equipment?

2. What is an SF unit and what are its purposes?

3. What equipment is connected to either side of the SF signaling unit?

4. What is the function of the SF unit?

5. What is the purpose of the foreign applique?

1-2. Operation of Interface Trunk Circuits

The basic trunk circuit (fig. 1,A on foldout 2 printed as separate enclosure) was designed for use as a two-way interface between a PABX and an AUTOVON switching center.

The circuit provides a means of completing incoming and outgoing routine and precedence level calls. AUTOVON preemption of an established call by a precedence or higher precedence level call, attendant preemption of established routine calls, network inward dialing, network outward dialing, and network inward dialing of precedence level calls.

Calls may be established between the PABX party and the AUTOVON party via this circuit with or without the assistance of the PABX attendant.

Network inward dialing calls are calls that are being established between the AUTOVON calling party and the PABX called party via the incoming selector without the assistance of the PABX attendent. The network outward dialing call is processed to the AUTOVON called station via the outgoing selector.

Precedence alerting and preempt signals from the distant AUTOVON switching center are detected by this circuit. The attendant can preempt a routine call in this trunk circuit. The AUTOVON switching center can preempt any call.

803. Using foldouts 2 and 3, (printed as separate enclosures) isolate the actions that occur in the interface trunk circuit during an NOD call and specify what effects these actions have on associated circuits.

There are two basic versions of wiring and figure options of the basic circuit. The first has "B" wiring. Use figure 2A (a part of foldout 3, found in a separate enclosure) here. This version is arranged to interface with a CONUS AUTOVON switch and has the PNID capabilities. The second version has "A" wiring, and figure 2A (on foldout 3) is not used here. This version is arranged to interface with an oversea AUTOVON switch and does not have the PNID capabilities; all incoming precedence level calls are directed to the PABX attendant via the board appliques.

Again, due to the complex wiring options and the flexibility of the basic trunk circuit, it would be impossible for us to study every type of circuit operation used in a PABX office. Therfore we will limit our study to the trunk, as if the circuit plate number was figure 27A, (H-75650-27A). Look at table A of foldout 3 (separate enclosure), there you will find that figure 27A consists of the following associated circuits wired together:

(1) Basic trunk circuit, figure 1A, foldout 3.
(2) Precedence in dialing control circuit, figure 2A, foldout 3.
(3) Transfer to attendant, figure 7A, foldout 3.
(4) Pad control circuit, figure 6A, foldout 3.

Table B of foldout 3 shows the different figures that can be used to adapt the PABX switchboard to the basic trunk circuit. We will only study figure 3,A, (foldout 3) for universal cord circuit. Figures 4A and 5A, which would normally be included in foldout 3, have been omitted from it to simplify the drawing.

The precedence in dialing control circuit, also shown in figure 2A of foldout 3, allows precedence incoming calls to a PABX telephone number that is busy or not answered within 12 to 15 seconds to be diverted to the attendant's cabinet.

The transfer to attendant circuit, shown in figure 7A of foldout 3, works in conjunction with the switchboard applique and the basic trunk circuit to allow NID calls to a PABX subscriber to be transferred to the attendant's cabinet.

The pad control circuit shown in figure 6A of foldout 3, allows a 2-db pad to be removed automatically if a call is being routed to or from a satellite exchange through a main PABX, or the switchboard attendant can remove it manually. By removing this pad, the transmission quality of the circuit is increased.

Now that you know the functions of the component parts of the basic trunk circuit, let us look at how they work as a system.

Network Outgoing Call From Incoming or Through Selector Bank or Rotary Switch. The first description of circuit operation, shown in foldouts 2 and 3, will be a call from a subscriber through a satellite exchange into our main exchange and into the AUTOVON switch. During this discussion and the others that follow, you will use the several schematics of foldouts 2 and 3 and the notes that they contain. Go slowly and trace all of the paths discussed.

Seizure. This circuit is marked idle to preceding equipment by absence of ground or −48 volts (via R6) on lead "C." When this circuit is seized, a loop via leads "+" and "−" is closed to relay A and number two winding of relay TS in figure 6A on foldout 3. Use coordiante C-1 for the correct T and R to start on. These actions occur:

(1) A operates and TS through its #2 winding—A contacts 7 and 8 completes a circuit to operate relay AS. A contacts 2 and 3 complete a circuit to operate relay B. A contacts 5 and 6 change lead M from its on-hook condition to its off-hook condition through the ballast lamp to battery. TS relay operates to its "X" contact only.

(2) B relay operates—B contacts 8 and 9 operate TS relay fully over the H6 lead. B contacts 6 and 7 complete a circuit to relay B2.

(3) TS relay operates—TS contacts 3 and 4 remove the 2-dB pad from T and R to increase transmission quality.

(4) B2 relay operates—B2 relay serves no function at this time.

(5) AS relay operates—AS contacts 4 and 5 complete a circuit to operate relay ON.

(6) ON relay operates—ON contacts 10 and 11 operate relay ONS. ON contacts 1 and 2 remove idle line termination (resistor R-1).

(7) ONS relay operates—ONS contacts 10B and 11B light routine busy lamp on switchboard. ONS contacts 4B and 5B place a ground on C-lead to hold the preceding switch train operated and mark the trunk busy. ONS contacts 6B and 7B place a ground on HU-lead to mark trunk busy, if rotary switch access is used. ONS contacts 10T and 11T complete a ld path for relay B2.

Outpulsing. After accessing the AUTOVON equipment, the subscriber dials the AUTOVON address. The dial opens and closes the loop to the two-way/four-way trunk, which applies and removes negative 48 volts on the M lead. The SF signaling unit converts the DC signals received on the M lead into 2,600-Hz tone-on/tone-off signals. The amplified tone bursts are sent to the switching equipment. These things follow:

(1) Impulse springs break—this opens the T and R loop to relay A.

(2) A relay releases—A contacts 7 and 8 opens the circuit to relay AS. A contacts 1 and 2 completes a circuit to operate relay C. A contacts 2 and 3 opens the circuit to relay B and puts it on slow to release. B remains operated during pulsing. A contacts 4 and 5 transfer lead M from its off-hook condition to its on-hook condition.

(3) AS relay releases—AS contacts 4 and 5 open circuit to ON and put it on slow to release.

(4) C relay operates—C contacts 6 and 7, 12 and 13 connect capacitors C-5 and C-6 in parallel with the repeat coils to insure proper pulsing of relay A by preventing inductive reactance of repeat coils from interfering with pulsing loop. C contacts 10 and 11 connect resistance battery via a combination of resistors R-18 to R-21 in multiple to #1 winding relay A (see note 3) to control percent make break of relay A.

(5) Impulse springs make—this closes the T and R loop to relay A.

(6) A relay operates—A contacts 7 and 8 close the circuit to relay AS. A contacts 1 and 2 open the circuit to relay C and puts it on slow to release. C remains operated during pulsing. A contacts 2 and 3 reclose a circuit to relay B. A contacts 5 and 6 transfer lead M from its on-hook condition to its off-hook condition.

(7) AS relay operates—AS contacts 4 and 5 close the circuit to relay ON. Relays B, ON, and C remain operated during pulsing due to their slow-to-release characteristics.

(8) Dial pause—during dial pause relay C releases.

(9) C relay releases—C serves no function at this time.

Called line idle. Relays operated when the called party answers are A, AS, B, ON, ONS, TS, and B2 in figure 2A on foldout 3. When the called party answers, the distant AUTOVON switching center removes SF tone causing the SF unit to ground lead E. Grounded lead E operates relay E. Next, these things happen:

(1) E Relay operates—E contacts 4 and 5 close a circuit to relay ES. E contacts 2 and 3 close a circuit to relay ESS.

(2) ESS relay operates—ESS relay serves no function at this time.

(3) ES relay operates—ES contacts 2 and 3 close a circuit to relay PT and SR in parallel.

(4) SR relay operates—SR relay serves no function at this time.

(5) PT relay operates—PT contacts 4 and 5 close a circuit to relay RV.

(6) RV relay operates—contacts 6T and 8T, 5B and 7B reverse the polarity of leads "+" and "−" to return answer supervision.

Conversation. Conversation between the PABX calling party and the AUTOVON called party takes place at this time. the following relays are operated during conversation: figure 1A of foldout 3—A, AS, B, ON, ONS, PT, SR, RV, E, ES, ESS; figure 6A of foldout 3—TS; and figure 2A—B2.

Called line busy. If the called line is busy, busy tone is returned to the calling party via the repeat coils from the distant end. Relays operated—A, AS, B, ON, ONS, and TS. Ground is *not* returned on the E lead from the SF unit.

Release from a busy condition. When the calling party disconnects from a busy condition, the loop to relay A is opened. The sequence will be the same as seizure, but instead of the relays operating, they will release.

Calling party disconnects first. When the calling party disconnects first, the loop to relay A is opened. Relay A releases. After this, these actions take place:

(1) A relay releases—A contacts 7 and 8 open the circuit to relay AS. A contacts 2 and 3 open the circuit to relay B and puts it on slow to release. Relay B times out and releases. A contacts 4 and 5 change lead M from its off-hook condition to its on-hook condition.

(2) AS relay releases—AS relay serves no function at this time.

(3) C relay operates—C relay serves no function at this time.

(4) B relay releases—B contacts 8 and 9 open the circuit to relay TS. B contacts 4 and 5 open the circuit to relay C and put it on slow to release. C times out and releases.

(5) TS relay releases—TS contacts 3 and 4 replace the 2-dB pad on T and R leads.

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(6) C relay releases—C relay serves no function at this time.

AUTOVON disconnects second. When the called party disconnects, ground is removed from the E lead opening the circuit to relay E. Thereafter this ensues:

(1) E relay releases—E contacts 4 and 5 open the circuit to relay ES. E contacts 2 and 3 open the circuit to relay ESS.

(2) ESS relay releases—ESS relay serves no function at this time.

(3) ES relay releases—ES contacts 2 and 3 open the circuit to relay SR and put it on slow to release. SR relay releases.

(4) SR relay releases—SR contacts 4 and 5 open the circuit to PT and put it on slow to release. PT relay times out and releases. SR contacts 1 and 2 complete a circuit to relay P.

(5) P relay operates—P relay serves no function at this time.

(6) PT relay releases—PT contacts 6 and 7 open the circuit to relay P. PT contacts 4 and 5 open the circuit to relay RV. PT contacts 4 and 5 open the circuit to relay ON and put it on slow to release. ON times out and releases.

(7) P relay releases—P relay serves no function at this time.

(8) RV relay releases—RV contacts 6T and 8T, 5B and 7B reverse the polarity of leads "+" and "−" to return answer supervision.

(9) ON relay releases—ON contacts 10 and 11 opens the circuit to relay ONS.

(10) ONS relay releases—ONS contacts 6B and 7B remove ground from the HU lead. ONS contacts 4B and 5B remove ground from the C lead. ONS contacts 10B and 11B remove ground from the BL-1 lead to extinguish the routine busy lamp. ONS contacts 10T and 11T open the circuit to relay B2 and put it on slow to release. B2 times out and releases. B2 relay serves no function at this time. The circuit is now at normal.

Called party disconnects first. When the called party disconnects first, AUTOVON returns the SF tone. The SF unit removes ground from the E lead, causing the E relay to release. Then these actions occur:

(1) E relay releases—E contacts 4 and 5 open the circuit to relay ES. E contacts 2 and 3 open the circuit to relay ESS.

(2) ESS relay releases—ESS relay serves no function at this time.

(3) ES relay releases—ES contacts 2 and 3 open the circuit to relay SR and put it on slow to release. SR releases.

(4) SR relay releases—SR contacts 4 and 5 open the circuit to PT and put it on slow to release. PT times out and releases. SR contacts 1 and 2 complete a circuit to relay P.

(5) P relay operates—P relay serves no function at this time.

(6) PT relay releases—PT contacts 6 and 7 open the circuit to relay P. PT contacts 4 and 5 open the circuit to relay RV.

(7) P relay releases—P relay serves no function at this time.

(8) RV relay releases—RV contacts 6T and 8T, 5B and 7B reverse the polarity of leads "+" and "−" to return answer supervision.

Calling party disconnects second. When the calling party disconnects, the loop to relay A is opened. After this, this follows:

(1) A relay releases—A contacts 7 and 8 open the circuit to relay AS. A contacts 2 and 3 open the circuit to relay B and put it on slow to release. Relay B times out and releases A contacts 1 and 2 complete a circuit to relay C. A contacts 4 and 5 change lead M from its off-hook condition to its on-hook condition.

(2) C relay operates—C relay serves no function at this time.

(3) B relay releases—B contacts 8 and 9 open the circuit to relay TS. B contacts 4 and 5 open the circuit to relay C and put it on slow to release. C times out and releases.

(4) TS relay releases—TS contacts 3 and 4 replace the 2-dB pad on T and R leads.

(5) C relay releases—C relay serves no function at this time.

(6) AS relay releases—AS contacts 4 and 5 open the circuit to ON and put it on slow to release. Relay ON times out and releases.

(7) ON relay releases—ON contacts 10 and 11 open the circuit to relay ONS.

(8) ONS relay releases—ONS contacts 10B and 11B extinguish the routine busy lamp. ONS contacts 4B and 5B remove ground from C lead. ONS contacts 6B and 7B remove ground from HU lead. ONS contacts 10T and 11T open the circuit to relay B2 and put B2 on slow to release. B2 times out and releases.

(9) B2 relay releases—B2 relay serves no function at this time. The circuit is now at normal.

Network Outgoing Call from Outgoing Selector Banks or Rotary Switch. This call will be the same as the previous NOD call, except that we will not use figure 6A on foldout 3. The TS relay will not operate. Since this call originates in our local central office, we will not need the TS relay in figure 6A on foldout 3 to remove the 2-dB pad; thus, the path for the A relay is different.

Exercises (803):

1. What prevents the preceding equipment from releasing when the interface trunk, shown in FO 2, is seized from an outgoing selector?

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2. **What action in the trunk circuit, shown in FO 2, alerts the SF unit that this circuit is no longer idle?**

3. **What function(s) are accomplished by relay A in the trunk circuit, shown in FO 2, during the second or subsequent impulse make?**

4. **What circuit actions occur when contacts 2 and 3 of relay ES, shown in FO 2, close?**

5. **What prevents the trunk circuit, shown in FO 2, from being seized prematurely when the calling party hangs up first?**

804. Using foldouts 2 and 3, distinguish the actions that occur in the interface trunk circuit during an NID call and indicate the effects those actions have on associated equipment.

NID Call to Incoming Selector From AUTOVON. This description of circuit operation (using figure 1A on foldout 2 and figure 2A on foldout 3, again) will be a call from AUTOVON into the interface equipment and out through the central office using the incoming selector and switch train to the called subscriber.

Seizure. Ground on the M lead marks this circuit idle. The grounded M lead causes the SF signaling unit to transmit 2,600-Hz signal to mark the circuit idle to AUTOVON. When the circuit is seized, AUTOVON removes the 2,600 Hz signal from the receiver which causes the SF signaling unit to ground the E-lead closing an operate path to relay E.

(1) E relay operates—E contacts 6 and 7 serve no function at this time due to a short circuit across leads B and B1 (terminals B6 and B5 respectively) coming from contacts 5 and 6 of relay DE, figure 2A on foldout 3. This short keeps the selector from stepping on the first digit. E (precedence digit) contacts 4 and 5 complete a circuit to relay ES. E contacts 2 and 3 complete a circuit to relay ESS.

(2) ES relay operates—ES contacts 2 and 3 complete a circuit to relay PT. ES contacts 2 and 3 complete a circuit to relay Sr. ES contacts 7 and 8 complete a circuit to relay IN.

(3) PT relay operates—PT relay serves no function at this time.

(4) SR relay operates—SR relay serves no function at this time.

(5) IN relay operates—IN contacts 8B and 9B complete a circuit to relay INS. IN contacts 2T and 3T, 2B and 3B, 4T and 5T, and 8T and 9T complete a loop to seize the incoming selector.

> NOTE: SP relay does not operate, due to magnetic opposition in its windings.

(6) INS relay operates—INS contacts 8 and 9 complete a circuit to relay IM.

(7) IM relay operates—IM contacts 8 and 9 provide a hold path for itself.

(8) ESS relay operates—ESS contacts 8 and 9 complete a circuit to relay ON. ESS contacts 8 and 9 complete a ground on lead C to mark the circuit busy to outgoing calls.

(9) ON relay operates—ON contacts 10 and 11 complete a circuit to relay ONS. ON contacts 1 and 2 remove the idle line termination. ON contacts 12 and 13 complete a circuit to relay WK.

(10) ONS relay operates—ONS contacts 4B and 5B complete an alternate ground on C lead. ONS contacts 6B and 7B ground HU lead. ONS contacts 10B and 11B complete a circuit to light the routine busy lamp on the switchboard. ONS contacts 4T and 5T change the path for relay IN from its operate path to its hold path.

(11) WK relay operates—WK contacts 5 and 6 complete a circut to relay B2.

> NOTE: WK relay connects lead WK2 to lead WK1, placing an off-hook condition on lead M. When WK relay releases, it disconnects lead WK2 from WK1, returning lead M to its on-hook condition. Wink-start signals, off-hook and then on-hook, on lead M is used to signal the distant AUTOVON switching center that the trunk is ready for pulsing and that the PABX has PNID capabilities. The timing for wink control will be 140 to 290 ms.

(12) B2 relay operates—B2 contacts 3 and 4 open the circuit to WK and put it on slow to release. WK times out and releases. B2 contacts 7 and 8 complete a hold path for it.

(13) WK relay releases—WK contacts 3 and 4 disconnect lead WK2 from WK1, returning lead M to its on-hook condition. Relays operated: E, ES, ESS, SR, PT, IN, INS, IM, ON, ONS, B2.

Pulsing of precedence digit. AUTOVON sends a series of tone-on/tone-off (on-hook/off-hook) bursts. The SF signaling unit converts this one tone bursts to ground pulses on lead E. During on-hook condition ground is removed from the E lead releasing relay E. The seized selector will not step on the precedence digit due to leads B and B1 being shorted. This shorts out the function of contacts 6 and 7 of relay E. The rotary switch in figure 2A on foldout 3 will step on the first digit only. We will use the digit four to show a routine call.

On-hook. The E relay will release and reoperate four times, but we will only show it once. The following three times are the same. After this, these actions occur:

(1) E relay releases—E contacts 4 and 5 open the circuit to relay ES. E contacts 2 and 3 open the circuit to relay ESS.

(2) ES relay releases—ES relay serves no function at this time.

(3) ESS relay releases—ESS contacts 1 and 2 complete a circuit to relay C.

(4) C relay operates—C contacts 10 and 11 complete a circuit to magnet RS1, figure 2A of foldout 3.

(5) RS1 magnet operates—the rotary switch is an indirect drive homing-type switch, it will only step when RS1 releases.

Off-hook. Ground is reapplied to the E lead reoperating relay E. This is followed by these actions:

(1) E relay operates—E contacts 4 and 5 complete a circuit to relay ES. E contacts 2 and 3 complete a circuit to relay ESS.

(2) ES relay operates—ES relay serves no function at this time.

(3) ESS relay operates—ESS contacts 1 and 2 open the circuit to relay C and put it on slow to release. Relay C will not time out during pulsing. ESS contacts 10 and 11 open the circuit to RS1 magnet.

(4) RS1 magnet releases—RS1 magnet will step the rotary switch to the dialed level. This will be the level 4 for a routine call.

Dial pause. During dial pause, relay C times out and releases. Thereafter, these things occur:

(1) C relay releases—C contacts 3 and 4 complete a circuit to relay DE.

(2) DE relay operates—DE contacts 5 and 6 will take the short off leads B and B1 (contacts 6 and 7 of E). The next digit received will step the incoming selector. DE contacts 1 and 2 will prevent RS1 from operating on subsequent digits.

Pulsing of PABX subscribers number, on-hook. This digit will step the incoming selector. We will use the digit 1, although this digit could be any from 1 to 0. Ground is removed from the E lead, releasing relay E. At this point, these actions happen:

(1) E relay releases—E contacts 4 and 5 open the circuit to relay ES. E contacts 2 and 3 open the circuit to relay ESS. E contacts 6 and 7 open the loop to the incoming selector.

(2) ES relay releases—ES relay serves no function at this time.

(3) ESS relay releases—ESS contacts 1 and 2 complete a circuit to relay C.

(4) C relay operates—C contacts 8 and 9 short out the resistance of SP windings during pulsing. C contacts 12 and 13, and 6 and 7 place capacitors C-5 and C-6 in parallel with repeat coil during pulsing. RS1 magnet will not operate due to contacts 1 and 2 of relay DE being open.

Off-hook. Ground is reapplied to E lead, reoperating relay E. Following this, these things happen:

(1) E relay operates—E contacts 4 and 5 complete a circuit to relay ES. E contacts 2 and 3 complete a circuit to relay ESS. E contacts 6 and 7 complete the loop to the incoming selector. The incoming selector has taken 1 step now.

(2) ES relay operates—ES relay serves no function at this time.

(3) ESS relay operates—ESS contacts 1 and 2 open the circuit to relay C and put it on slow to release. C will not release during pulsing.

Dial pause. C relay times out and releases during dial pause. Next, these things take place: C contacts 8 and 9 open the short on the SP windings. C contacts 12 and 13, and 6 and 7 removes capacitors C-5 and C-6 from the circuit.

Called party answers. The incoming selector will switch through to the 2d selector or connector, depending upon the PABX trunking, and the following digits will step these switches to the called party. When the called party answers, the connector will reverse T and R, which reverses battery and ground going to the windings of relay SP, causing it to operate. After this, these actions ensue:

(1) SP relay operates—SP contacts 1 and 2 complete a circuit to relay INA. SR contacts 1 and 2 complete a circuit to relay SPS.

(2) INA relay operates—INA completes a hold path for itself through contacts 1 and 2.

(3) SPS relay operates—SPS contacts 6B and 7B change lead M from on-hook to off-hook condition to signal the distant end equipment that the called party has answered. SPS contacts 9T and 10T complete a circuit to relay SD.

(4) SD relay operates—SD contacts 12 and 13 short leads M6 and M0 for off-hook supervision. If relay SPS releases, the circuit will not indicate on-hook until both parties release. Conversation between the calling AUTOVON party and the called PABX party takes place at this ime.

The following relays are operated during conversation: figure 1A on foldout 2—E, ES, ESS, SR, PT, IN, INS, IM, SP, SPS, INA, ON, ONS; figure 2A on foldout 3—B2, DE; and figure 7A on foldout 3—SD.

Release, calling party disconnects first. When the calling party disconnects first, AUTOVON returns 2,600 Hz, causing the SF signaling unit to remove the ground on E lead, releasing the E relay. At this point, this happens:

(1) E relay releases—E contacts 4 and 5 open the circuit to relay ES. E contacts 2 and 3 open the circuit to relay ESS.

(2) ESS relay releases—ESS contacts 1 and 2 complete a circuit to relay C.

(3) ES relay releases—ES contacts 2 and 3 open the circuit to relay SR and put it on slow to release. SR times out and releases.

(4) C relay operates—C relay serves no function at this time.

(5) SR relay releases—SR contacts 4 and 5 open the circuit to relay PT and put it on slow to release. PT times out and releases. SR contacts 1 and 2 complete a circuit to relay P.

(6) P relay operates—P contacts 9 and 11 provide a hold path for itself.

(7) PT relay releases—PT contacts 6 and 7 open the circuit to relay P. PT contacts 8 and 9 open the circuit to relay C and put C on slow to release. C times out and releases.

(8) P relay releases—P relay serves no function at this time.

(9) DE relay releases—DE contacts 3 and 4 complete a homing circuit to RS1.

(10) RS1 magnet operates--rotary switch RS1 steps self-interruptedly to its home position and opens its "ON" contacts opening its homing circuit.

(11) INS relay releases—INS contacts 8 and 9 open the circuit to relay IM. INS contacts 4 and 5 open the circuit to relay SD and TR relay to "X" contacts. INS contacts 2 and 3 remove ground on HU lead.

(12) TR relay releases—TR relay serves no function at this time.

(13) IM relay releases—IM relay serves no function at this time.

(14) SD relay releases—SD contacts 1 and 2 return the M lead from its off-hook condition to its on-hook condition. The circuit is now at normal.

Called party disconnects first. When the PABX called party disconnects first, normal polarity is restored to leads +L and −L via the incoming selector, closing the windings of SP in magnetic opposition. Relay SP restores, then these actions occur:

(1) SP relay releases—SP contacts 1 and 2 open the circuit to relay SPS.

(2) SPS relay releases—SPS contacts 8T and 9T operate relay TR to its "X" contacts only and holds relay SD.

(3) TR relay operates to "X" contacts—TR relay serves no function at this time.

Calling party disconnects second. When the AUTOVON calling party disconnects second, ground is removed from lead E releasing relay E. Following this, these events take place:

(1) E relay releases—E contacts 6 and 7 open the circuit to the incoming selector releasing the PABX switch train. E contacts 2 and 3 open the circuit to relay ESS. E contacts 4 and 5 open the circuit to relay ES.

(2) ESS relay releases—ESS contacts 1 and 2 complete a circuit to relay C.

(3) ES relay releases—ES contacts 2 and 3 open the circuit to relay SR and put it on slow to release. SR times out and releases.

(4) C relay operates—C relay serves no function at this time.

(5) SR relay releases—SR contacts 1 and 2 complete a circuit to relay P. SR contacts 2 and 3 open the circuit to relay PT and put it on slow to release. PT times out and releases.

(6) P relay operates—P contacts 9 and 11 provide a hold path for itself.

(7) PT relay releases—PT contacts 6 and 7 open the circuit to relay P. PT contacts 4 and 5 open the circuit to relay ON and put it on slow to release. ON times out and releases. PT contacts 8 and 9 open the circuit to relay C and put it on slow to release. Relay C times out and releases.

(8) P relay releases—P relay serves no function at this time.

(9) C relay releases—C relay serves no function at this time.

(10) ON relay releases—ON contacts 10 and 11 open the circuit to relay ONS.

(11) ONS relay releases—ONS contacts 10B and 11B extinguish the routine busy lamp. ONS contacts 10T and 11T open the circuit to relay B2 and put it on slow to release. B2 times out and releases. ONS contacts 4T and 5T open the circuit to relay IN. ONS contacts 4B and 5B remove ground on C lead.

(12) B2 relay releases—B2 relay serves no function at this time.

(13) IN relay releases—IN contacts 6T and 7T open the circuit to relay INA. IN contacts 8B and 9B open the circuit to relay INS. IN contacts 6T and 7T open the circuit to relay DE.

(14) INA relay releases—INA relay serves no function at this time.

(15) DE relay releases—DE contacts 3 and 4 complete a homing circuit to magnet RS1.

(16) RS1 magnet operates—Rotary switch RS1 steps self-interruptedly to its home position and opens its "ON" contacts, opening its homing circuit.

(17) INS relay releases—INS contacts 8 and 9 open the circuit to relay IM. INS contacts 4 and 5 open the circuit to relay SD and relay TR to its "X" contacts. INS contacts 2 and 3 remove ground on HU lead.

(18) IM relay releases—IM relay serves no function at this time.

(19) TR relay releases—TR relay serves no function at this time.

(20) SD relay releases—SD contacts 1 and 2 return the M lead from its off-hook condition to its on-hook condition. The circuit is now at normal.

Exercises (804):

1. What piece of equipment alerts the trunk, shown in foldout 2, of an incoming call and how is it done?

2. What relay operation, in the trunk circuit, shown in foldout 2, seizes the incoming selector switch for an NID call?

3. What action marks the trunk circuit, shown in foldout 2, busy to NOD calls, during an NID call, when rotary switch access is used?

4. When the first digit is pulsed into the trunk circuit, shown in foldout 2, what prevents it from stepping the incoming selector?

5. What action takes place in the trunk circuit in response to the first digit?

6. What trunk circuit action steps the incoming equipment (selector(s) and connectors) during an NID call?

7. When RS1 returns to its home position during trunk release from an NID call, what causes it to stop at the home position?

1-3. Troubleshooting Interface Trunk Circuits

In this chapter and the next, a little spice has been added to the troubleshooting sections; the spice being complexity. Anytime you are requir-d to go from one schematic to aother you have some complexity. AUTOVON circuits get a lot of interest at higher levels when trouble develops. The quicker you get it fixed, the happier your Chief of Maintenance will be.

805. Given interface trunk circuit trouble symptoms and using foldouts 2 and 3, isolates the probable causes in trouble in each such situation and pinpoint the corrective action for each such situation.

One of the objectives of this volume is to familiarize you with the AUTOVON interface equipment operation and troubleshooting. Another is to help you get over the very natural reaction of "Oh my gosh," when you first glance at a complex schematic.

Remember the systematic approach to troubleshooting that you have been using along with the knowledge of how the circuit works; then troubleshooting this equipment should not be as tough as you first think it is.

Exercises (805):

Complete the following troubleshooting problems, using foldouts 2 and 3 as needed.

1. What is the trouble, when after a subscriber has fully seized the trunk during an NOD call, another local subscriber cuts into the same trunk circuit? Contacts 4B and 5B of relay ONS are clean and making. What is the corrective action?

2. On an NID call the selector steps in response to the first incoming digit. What is the probable cause of the trouble and what should be done to correct it? The trouble is not located in figure 1A on foldout 2 of the trunk circuit.

3. The operator plugs into the routine jack on the switchboard, and finds that an NOD call is in progress. The routine busy lamp on the switchboard is not burned out even though it was not lit. What is the trouble and how should you correct it?

4. On an NID call, the condition of the M lead does not change to indicate to the distant office that it is ready to receive digits. The trouble is not to be found in figure 1A on foldout 2. What is the trouble and the corrective action? Contacts 3 and 4 of the WK relay are clean.

CHAPTER 2

Other Interface Circuits

IN THIS CHAPTER, we discuss the processing of precedence calls through the trunk from and to the switchboard. We will also cover the workings of the foreign applique circuit for the German manufactured Siemans RP40 exchanges as well as the operation of SF units and VF line amplifiers.

After each section about circuit operations, you will do some troubleshooting to reenforce your understanding of circuit operations and equipment interactions.

2-1. Switchboard Applique Circuit and DTMF Keyset

The switchboard applique circuit used with the basic trunk circuit enables the operator to place calls into the AUTOVON system. Switchboards may be wired (1) for routine calls only or (2) for both routine and precedence calls.

Along with the applique circuit, a DTMF keyset is connected into the switchboard circuitry for the placing of precedence calls as well as routine calls. In Chapter 1 of this volume, we discussed the DTMF keyset; in this chapter we will see how it is connected into the switchboard.

806. Using figures 2-1 and 2-2 and foldouts 3 and 4 as necessary, identify the actions that occur in the switchboard applique circuit, interface trunk circuits, and DTMF keyset during a precedence outgoing call from the attendant's cabinet and clarify what effects those actions have on associated equipment.

In this section we work with the switchboard applique circuit; which, in spite of its fancy name consists of little more than a few relays, as shown in figures 3A, JK2, and sometimes JK1 (for precedence calls) in foldout 3.

The DTMF keyset hooks up to the attendant's cabinet, as shown in figure 2-1. The DTMF keyset contains a tone generator, a 16-key pushbutton unit (fig. 1-9), a common switch, a coupling circuit, and a voltage regulator circuit. Figure 2-2 shows how these units are hooked together, as does foldout 4. You should recall that two tones are generated by pushing a specific button on the keyset and, also, that these tones go to the AUTOVON switch without being changed into tone bursts by the SF unit. The precedence network out dial (PNOD) from the attendant cabinet to the AUTOVON network and precedence network in dial (PNID) from the AUTOVON network to the attendance cabinet will be discussed.

You will use some of the same schematics that we have discussed in Chapter 1. There will be some slight differences, but at least the ground you go over should be familiar to you.

Precedence Outgoing Call from the Attendant's Cabinet. This description of circuit operation will be a priority call from an operator at the switchboard into the interface equipment, out to AUTOVON switch.

Seizure. When the attendant inserts the call cord into the precedence jack, ground via the K lead of JK1 operates relay JP, shown in figure 3A on foldout 3. A loop is also closed to relay A when the operator inserts the call cord into JK1. The figures used in this call are foldout 2, figure 1A, and foldout 3, figures 2A, 3A, and JK1. Use coordinate C-1 for the correct T and R to start on. At this point:

(1) JP relay operates—JP contacts 12T and 13T complete a circuit to relay PBY. JP contacts 4B and 5B complete a circuit to relay AL. JP contacts 6B and 7B complete a circuit to operate relay OP1 to its "X" contacts. JP contacts 8T and 9T complete a circuit to relay PSL. JP contacts 12B and 13B complete a circuit to ground the sleeve of the cord supervisory circuit for cord supervision. The cord supervisory lamp lights. JP contacts 10T and 11T provide a hold path for JP.

(2) A relay operates—A contacts 7 and 8 complete a circuit to relay AS. A contacts 2 and 3 complete a circuit to relay B. A contacts 4, 5, and 6 change the M lead from its on-hook condition to its off-hook condition.

(3) AL relay operates—AL relay serves no function at this time.

(4) OP1 relay operates—OP1 relay operates to its "X" contacts 1 and 2, providing its full operating path and hold path.

(5) PSL relay operates—PSL contacts 12B and 13B light the precedence busy lamp on the switchboard.

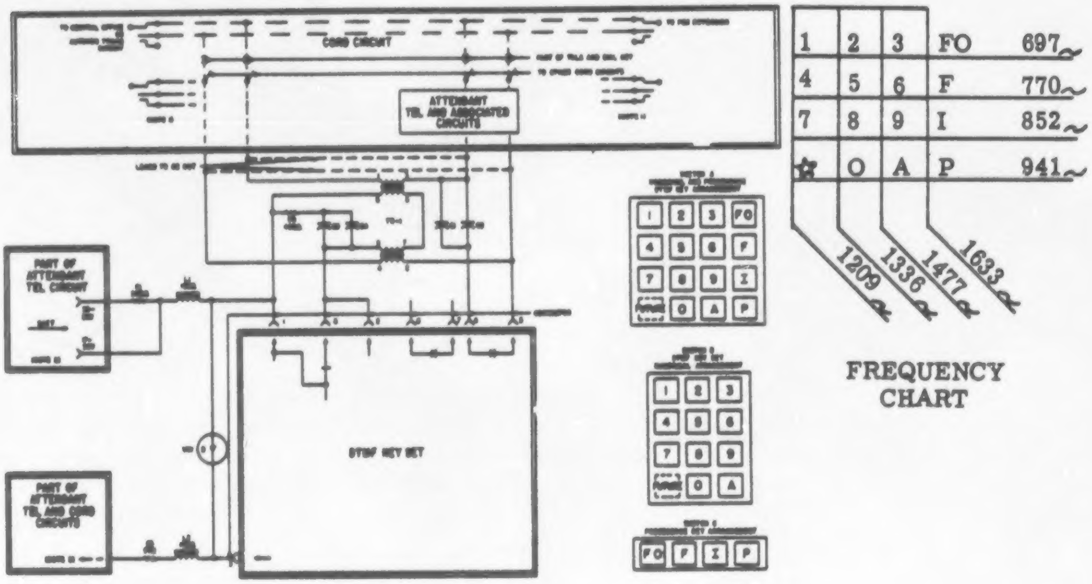

Figure 2-1. PABX SWBD DTMF position and cord circuit modification.

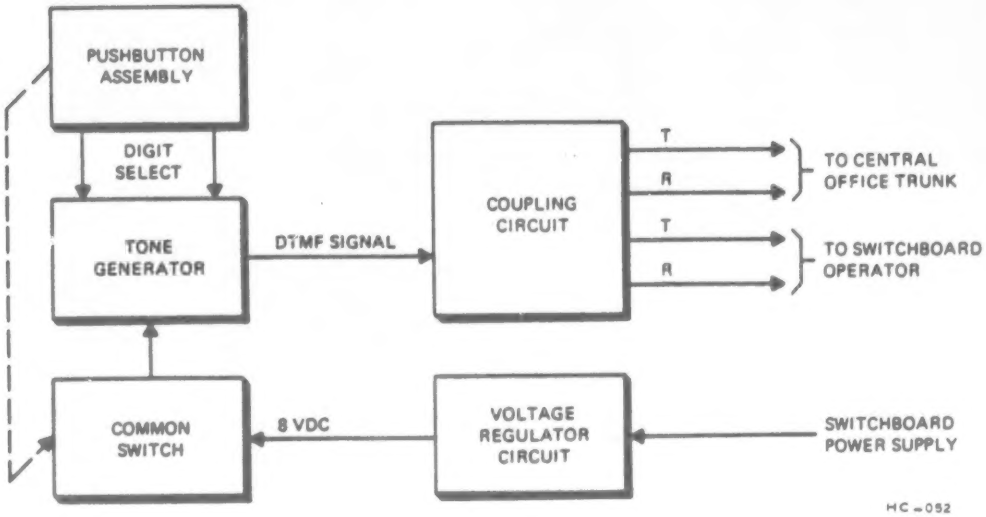

Figure 2-2. DTMF keyset equipment, functional block diagram.

(6) PBY relay operates—PBY contacts 12B and 13B complete a circuit to relay P2. PBY contacts 12B and 13B complete a circuit to the routine busy lamp.

(7) P2 relay operates—P2 relay serves no function at this time.

(8) B relay operates—B contacts 6 and 7 complete a circuit to relay B2.

(9) B2 relay operates—B2 relay serves no function at this time.

(10) AS relay operates—AS contacts 4 and 5 complete a circuit to relay ON.

(11) ON relay operates—ON contacts 8 and 9 complete a hold path for relay PSL. ON contacts 10 and 11 complete a circuit to relay ONS. ON contacts 1 and 2 remove idle line termination.

(12) ONS relay operates—ONS contacts 6B and 7B ground the HU lead. ONS contacts 4B and 5B ground the C lead. ONS contacts 4T and 5T complete a hold path for relay AL. ONS contacts 12T and 13T complete a hold path for PBY. ONS contacts 12B and 13B complete a hold path for P2. ONS contacts 10T and 11T complete a hold path for B2.

Outpulsing. The attendant sends DTMF signals via T and R leads to AUTOVON switch. Relays operated at this time are: figure 1A on foldout 2—OP1, PSL, PBY, P2, A, AS, B, ON, ONS; figure 2A on foldout 3—B2; and figure 3A on foldout 3—JP, AL.

AUTOVON called party answers. When the called party answers, ground on the E lead is returned from the SF signaling unit due to the tone-off condition on the receive line. Relay E operates. These actions follow:

(1) E relay operates—E contacts 2 and 3 complete a circuit to relay ESS. E contacts 4 and 5 complete a circuit to relay ES.

(2) ESS relay operates—ESS relay serves no function at this time.

(3) ES relay operates—ES contacts 2 and 3 complete a circuit to relay SR. ES contacts 2 and 3 complete a circuit to relay PT.

(4) SR relay operates—SR relay serves no function at this time.

(5) PT relay operates—PT contacts 4 and 5 close a circuit to relay RV.

(6) RV relay operates—RV contacts 6T and 8T, 5B and 7B reverse the polarity of leads T and R. RV contacts 1T and 2T open the ground on the sleeve to the cord supervisory circuit in conjunction with battery reversal for SWBD cord supervision. The cord supervisory lamp goes out.

Conversation. Conversation between the calling PABX operator and the called party takes place at this time. The following relays are operated during conversation: figure 1A on foldout 2—OP1, PSL, PBY, P2, A, AS, B, ON, ONS, E, ES, ESS, RV, SR, and PT; figure 3A on foldout 3—JP, AL; and figure 2A on foldout 3—B2.

Called line busy. If the called line is busy or the called party does not answer within 12 seconds, the PABX equipment at the distant end will divert the call to the operator. Therefore, the sequence will be the same as the called party answering.

Release, calling party disconnects first. When the attendant disconnects first by removing the call cord from jack JK1, the loop to relay A is opened and ground is removed from the K lead, restoring relay JP. This is where these things occur:

(1) JP relay releases—JP contacts 6B and 7B open the circuit to relay OP1.

(2) A relay releases—A contacts 7 and 8 open the circuit to relay AS. A contacts 2 and 3 open the circuit to relay B and put it on slow to release. Relay B times out and releases. A contacts 1 and 2 complete a circuit to relay C. A contacts 4 and 5 change lead M from its off-hook condition to its on-hook condition.

(3) OP1 relay releases—OP1 relay serves no function at this time.

(4) AS relay releases—AS relay serves no function at this time.

(5) C relay operates—C relay serves no function at this time.

(6) B relay releases—B contacts 4 and 5 open the circuit to relay C and put it on slow to release. C times out and releases.

(7) C relay releases—C relay serves no function at this time.

AUTOVON disconnects second. When the called party disconnects, ground is removed from the E lead, opening the circuit to relay E. Here the following happens:

(1) E relay releases—E contacts 4 and 5 open the circuit to relay ES. E contacts 2 and 3 open the circuit to relay ESS.

(2) ESS relay releases—ESS relay serves no function at this time.

(3) ES relay releases—ES contacts 2 and 3 open the circuit to relay SR and put it on slow to release. SR times out and releases.

(4) SR relay releases—SR contacts 4 and 5 open the circuit to relay PT and put it on slow to release. PT times out and releases. SR contacts 1 and 2 complete a circuit to relay P.

(5) P relay contacts 9 and 11—these complete a hold path for itself. P contacts 7 and 8 complete a circuit to relay PR.

(6) PR relay operates—PR contacts 9T and 10T complete an alternate ground for the precedence busy lamp. PR contacts 7B and 8B provide a hold path for itself.

(7) PT relay releases—PT contacts 6 and 7 open the circuit to relay P. PT contacts 4 and 5 open the circit to relay RV. PT contacts 4 and 5 open the circuit to relay ON and put it on slow to release. ON times out and releases.

(8) P relay releases—P relay serves no function a. this time.

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(9) RV relay releases—RV contacts 6T and 8T, 5B and 7B reverse the polarity of leads T and R for reverse battery supervision.

(10) ON relay releases—ON contacts 10 and 11 open the circuit to relay ONS. ON contacts 8 and 9 open the circuit to relay PSL.

(11) PSL relay releases—PSL contacts 12B and 13B open the circuit to relay PR. PSL contacts 12B and 13B open the ground on lead HU.

(12) PR relay releases—PR contacts 9T and 10T extinguish the precedence busy lamp.

(13) ONS relay releases—ONS contacts 12T and 13T open the circuit to relay PBY. ONS contacts 12B and 13B open the circuit to relay P2. ONS contacts 4T and 5T open the circuit to relay AL. ONS contacts 4B and 5B remove the ground on C lead. ONS contacts 10T and 11T open the circuit to relay B2 and put it on slow to release. B2 times out and releases.

(14) PBY relay releases—PBY contacts 12B and 13B extinguish the routine busy lamp.

(15) P2 relay releases—P2 relay serves no function at this time.

(16) AL relay releases—AL relay serves no function at this time.

(17) B2 relay releases—B2 relay serves no function at this time. The circuit is now at normal.

Called party disconnects first. When the called party disconnects first, AUTOVON returns the 2,600-Hz SF tone, causing the SF signaling unit to remove the ground on lead E. E relay releases. This is where these things occur:

(1) E relay releases—E contacts 4 and 5 open the circuit to relay ES. E contacts 2 and 3 open the circuit to relay ESS.

(2) ESS relay releases—ESS relay serves no function at this time.

(3) ES relay releases—ES contacts 2 and 3 open the circuit to relay SR and put it on slow to release. SR times out and releases.

(4) SR relay releases—SR contacts 4 and 5 open the circuit to relay PT and put it on slow to release. PT times out and releases. SR contacts 1 and 2 complete a circuit to relay P.

(5) P relay operates—P contacts 9 and 11 complete a hold path for itself. P contacts 7 and 8 complete a circuit to relay PR.

(6) PR relay operates—PR contacts 9T and 10T complete an alternate ground for the precedence busy lamp. PR contacts 7B and 8B provide a hold path for itself.

(7) PT relay releases—PT contacts 6 and 7 open the circuit to relay P. PT contacts 4 and 5 open the circuit to relay RV.

(8) P relay releases—P relay serves no function at this time.

(9) RV relay releases—RV contacts 6T and 8T, 5B and 7B reverse the polarity of leads T and R to return answer supervision. RV contacts 1T and 2T ground the sleeve of the cord supervisory circuit for SWBD supervision in conjunction with reverse battery. The cord supervisory lamp lights.

Calling party disconnects second. The attendant removes the call cord from jack JK1. This opens the loop to relay A, and removes ground from the K lead releasing relay JP. Next, these things happen:

(1) JP relay releases—JP contacts 6B and 7B open the circuit to relay OP1.

(2) OP1 relay releases—OP1 relay serves no function at this time.

(3) A relay releases—A contacts 7 and 8 open the circuit to relay AS. A contacts 2 and 3 open the circuit to relay B and put it on slow to release. B times out and releases. A contacts 1 and 2 complete a circuit to relay C. A contacts 4 and 5 change lead M from its off-hook condition to its on-hook condition.

(4) C relay operates—C relay serves no function at this time.

(5) B relay releases—B contacts 4 and 5 open the circuit to relay C and put it on slow to release. C times out and releases.

(6) C relay releases—C relay serves no function at this time.

(7) AS relay releases—AS contacts 4 and 5 open the circuit to relay ON and put it on slow to release. ON times out and releases.

(8) ON relay releases—ON contacts 10 and 11 open the circuit to relay ONS. ON contacts 8 and 9 open the circuit to relay PSL.

(9) PSL relay releases—PSL contacts 12B and 13B open the circuit to relay PR. PSL contacts 12B and 13B remove ground from lead HU.

(10) PR relay releases—PR contacts 9T and 10T extinguish the precedence busy lamp.

(11) ONS relay releases—ONS contacts 12T and 13T open the circuit to relay PBY. ONS contacts 12B and 13B open the circuit to relay P2. ONS contacts 4T and 5T open the circuit to relay AL. ONS contacts 4B and 5B remove ground from lead C. ONS contacts 10T and 11T open the circuit to relay B2 and put it on slow to release. B2 times out and releases.

(12) PBY relay releases—PBY contacts 12B and 13B extinguish the routine busy lamp.

(13) P2 relay releases—P2 relay serves no function at this time.

(14) AL relay releases—AL relay serves no function at this time.

(15) B2 relay releases—B2 relay serves no function at this time. The circuit is now at normal.

Precedence Outgoing Call from the Attendant's Cabinet, When All Access Lines Are Busy. To obtain an access line for a high precedence outgoing call when all trunks are busy with precedence calls, the attendant must break in on the lowest preedence call and announce that the access line must be used for a higher precedence call. The attendant then disconnects the established call and reseizes the access line after it becomes idle. The subsequent operation is the same as the precedence outgoing call already described.

Exercises (806):

1. What is the relay operation that causes the precedence busy lamp to light? Start at the applique circuit.

2. When the operator seizes the trunk for a precedence call, what prevents a PABX subscriber at either end from accessing the trunk?

3. What is the relay operation that causes the cord supervisory lamp to go out on a PNOD call? Start by changing the condition of the E lead.

4. During the release of a precedence outgoing call from the switchboard, what prevents the local trunk circuit from being seized by a local subscriber or the operator, when the operator disconnects first, until the distant subscriber hangs up?

5. When the operator removes the cord from the precedence jack and relay JP releases, what is the path that keeps the precedence busy lamp lit?

6. When the operator depresses button 6 on the DTMF keyset, what occurs and what is the resulting circuit action? (Use foldout 4.)

807. Using figure 1A on foldout 2 and figure 3A on foldout 3 as needed, identify the actions that occur in the switchboard applique and interface trunk circuits during a PNID call and state what effects those actions have on associated circuits.

Now that you have gone through a PNOD call, let us see how these circuits work during a PNID call that is diverted to the attendant's cabinet.

Diversion of a PNID Call Not Answered Within 12 Seconds. This description of circuit operation will be similar to a PNID call. The difference in circuit operation will come when the 12-second timer times out and the called party has not answered.

Seizure. When AUTOVON goes off-hook, ground is applied to lead E via the SF signaling unit. Relay E operates. Here these actions follow:

(1) E relay operates—E contacts 4 and 5 complete a circuit to relay ES. E contacts 2 and 3 complete a circuit to relay ESS.

(2) ES relay operates—ES contacts 2 and 3 complete a circuit to relay PT. ES contacts 2 and 3 complete a circuit to relay SR. ES contacts 7 and 8 complete a circuit to relay IN.

(3) ESS relay operates—ESS contacts 8 and 9 complete a circuit to relay ON. ESS contacts 8 and 9 complete a circuit to mark the trunk busy to outgoing calls by grounding lead C.

(4) PT relay operates—PT relay serves no function at this time.

(5) SR relay operates—SR relay serves no function at this time.

(6) IN relay operates—IN contacts 8B and 9B complete a circuit to relay INS. IN contacts 2T and 3T, 2B and 3B, 4T and 5T, 8T and 9T complete a loop to seize the incoming selector.

(7) INS relay operates—INS contacts 8 and 9 complete a circuit to relay IM.

(8) IM relay operates—IM contacts 8 and 9 provide a hold path for itself.

(9) ON relay operates—ON contacts 10 and 11 complete a circuit to relay ONS. ON contacts 1 and 2 removes the idle line termination. ON contacts 12 and 13 complete a circuit to relay WK.

(10) ONS relay operates—ONS contacts 4B and 5B complete an alternate ground on lead C. ONS contacts 6B and 7B ground the HU lead. ONS contacts 10B and 11B complete a circuit to light the routine busy lamp on the switchboard. ONS contacts 4T and 5T change the path for relay IN from its operate path to its hold path.

(11) WK relay operates—WK contacts 5 and 6 complete a circuit to relay B2. WK contacts 3 and 4 connect lead WK2 to lead WK1, placing an off-hook condition on lead M starting the wink-start signal to AUTOVON.

(12) B2 relay operates—B2 contacts 3 and 4 open the circuit to WK and put it on slow to release. WK times out and releases. B2 contacts 7 and 8 complete a hold path for itself.

(13) WK relay releases—WK contacts 3 and 4 disconnect lead WK2 from WK1, returning lead M to its on-hook condition, ending the wink-start signal to AUTOVON.

Pulsing of precedence digit; on-hook. AUTOVON will send the precedence digit (1, 2, 3, or 0) after receiving the wink-start signal. This is done with a series of tone-on/tone-off (on-hook/off-hook) tone burst. During on-hook, ground is applied to the E lead via the SF signaling unit releasing relay E. At this point, these things take place:

(1) E relay releases—E contacts 4 and 5 open the circuit to relay ES. E contacts 2 and 3 open the circuit to relay ESS.

(2) ES relay releases—ES relay serves no function at this time.

(3) ESS relay releases—ESS contacts 1 and 2 complete a circuit to relay C.

(4) C relay operates—C contacts 10 and 11 complete a circuit to RS1.

(5) RS1 magnet operates—rotary switch RS1 is an indirect drive switch. It will only step when RS1 releases.

Off-hook. Ground is reapplied to the E lead reoperating relay E. Next, these actions take place:

(1) E relay operates—E contacts 4 and 5 complete a circuit to relay ES.

(2) ES relay operates—ES relay serves no function at this time.

(3) ESS relay operates—ESS contacts 1 and 2 open the circuit to relay C and put it on slow to release. Relay C will not time out during pulsing. ESS contacts 10 and 11 open the circuit to RS1.

(4) RS1 magnet releases—RS1 will step the rotary switch to the dialed level.

Dial pause. During dial pause relay C times out and releases. These things next happen:

(1) C relay releases—C contacts 3 and 4 complete a circuit to relay DE.

(2) DE relay operates—DE contacts 7 and 8 provide a hold path for itself. DE contacts 9 and 10 complete a circuit to relay PR. DE contacts 5 and 6 will remove the short on leads B and B1. The next digits received will step the PABX switch train.

(3) PR relay operates—PR contacts 9T and 10T complete a circuit to the precedence busy lamp. PR contacts 7T and 8T complete a circuit to relay AR.

(4) AR relay operates—AR contacts 6T and 7T, 8B and 9B complete a circuit via the repeat coils to return precedence ring back tone. AR contacts 12B and 13B complete a circuit to start the 12-second timer of timer T2. AR contacts 5B and 6B, 2B and 3B change the loop to the incoming selector.

Pulsing of PABX subscriber's number; on-hook. AUTOVON will now send on-hook/off-hook signals to step the PABX switch train to the called subscriber. Ground is removed from the E lead releasing relay E. This is where these actions occur:

(1) E relay releases—E contacts 4 and 5 open the circuit to relay ES. E contacts 2 and 3 open the circuit to relay ESS. E contacts 6 and 7 open the loop to the incoming selector.

(2) ES relay releases—ES relay serves no function at this time.

(3) ESS relay releases—ESS contacts 1 and 2 complete a circuit to relay C.

(4) C relay operates—C contacts 8 and 9 short out the resistance of SP winding during pulsing. C contacts 12 and 13, 6 and 7 place capacitors C-5 and C-6 in parallel with repeat coils during pulsing.

Off-hook. Ground is reapplied to E lead, reoperating relay E. Here these actions happen:

(1) E relay operates—E contacts 4 and 5 complete a circuit to relay ES. E contacts 2 and 3 complete a circuit to relay ESS. E contacts 6 and 7 complete the loop the incoming selector. The selector has taken one step now. Pulsing of the other digits would be the same.

(2) ES relay operates—ES relay serves no function at this time.

(3) ESS relay operates—ESS contacts 1 and 2 open the circuit to relay C and puts it on slow to release. C will not time out during pulsing.

Dial pause. C relay times out and releases during dial pause. C relay releases—C contacts 8 and 9 open the short on the SP windings. C contacts 12 and 13, 6 and 7 remove capacitors C-5 and C-6 from the circuit.

PNID call not answered within 12 seconds. Because the call is a precedence call, if the subscriber fails to answer or the line is busy over 12 seconds, the call will be diverted to the attendant. This is started by timer T2 timing out and placing a ground on the output punching No. 7. This ground operates relay RBL.

RBL relay operates—RBL contacts 8 and 10 provide a hold path for itself. RBL contacts 4 and 5 complete a circuit to flash the precedence answer lamp at 60 IPM. RBL contacts 6 and 7 prepares a path for relay JP when the attendant answers.

Attendant answers. The attendant will recognize the call as a diverted precedence call because of the flashing answer lamp. He will answer the call by inserting the answer cord into the precedence jack JK1. Ground via lead K operates relay JP. Here, watch for these actions:

(1) JP relay operates—JP contacts 5T and 6T extinguish the flashing precedence answer lamp. JP contacts 10T and 11T provide a hold path for itself. JP contacts 6B and 7B complete a circuit to relay OP1. JP contacts 12T and 13T complete a circuit to relay PBY. JP contacts 8T and 9T complete a circuit to relay PSL. JP contacts 4B and 5B complete a circuit to relay AL.

(2) OP1 relay operates—OP1 "X" contacts 1 and 2 insure a lockup path and hold path for itself before PBY contacts 1 and 2 break its operate path.

NOTE: PBY is a slow to operate relay.

(3) PBY relay operates—PBY contacts 12B and 13B complete a circuit to relay P2 and provide an alternate ground to the routine busy lamp.

(4) P2 relay operates—P2 contacts 3 and 4 complete a hold path for itself.

(5) PSL relay operates—PSL contacts 3B and 4B open the circuit to relay PBL. PSL contacts 7B and 8B provide an alternate ground for the routine busy lamp. CONTACTS 12B AND 13 B PROVIDE AN ALTERNATE GROUND FOR THE PRECEDENCE BUSY LAMP.

(6) RBL relay releases—RBL relay serves no function at this time.

(7) AL relay operates—AL contacts 1 and 2 open the hold path for relay IN and put it on slow to relase. IN times out and relases.

(8) IN relay releases—IN contacts 8B and 9B open the circuit to relay INS. IN contacts 1T and 2T, 1B and 2B complete a circuit to relay A via the attendant's cord circuit. IN contacts 2T and 3T, 2B and 3B, 4T and 5T, 8T and 9T open the circuit to the incoming selector and PABX switch train. IN contacts 6T and 7T open the circuit to relay DE.

(9) DE relay releases—DE relay serves no function at this time.

(10) INS relay releases—INS contacts 1 and 2 complete a circuit to relay RV.

(11) RV relay operates—RV contacts 6T and 8T, 5B and 7B reverse the polarity of T and R. RV contacts 1T and 2T open the sleeve of JK1. This provides for proper SWBD supervision in conjunction with reverse battery.

(12) A relay operates—A contacts 7 and 8 complete a circuit to relay AS. A contacts 2 and 3 complete a circuit to relay B. A contacts 5 and 6 place -48V on the M lead (off-hook) to signal the distant end that the called party has answered. This places the off-hook supervision on the M lead under control of the attendant.

(13) AS relay operates—AS relay serves no function at this time.

(14) B relay operates—B contacts 1 and 2 open the circuit to relay AR.

(15) AR relay releases—AR contacts 6T and 7T, 8B and 9B remove the precedence ring back tone.

Conversation. Conversation between the operator and the calling subscriber can now take place. The operator will complete the call as required. The following relays are operated during conversation: figure 1A on foldout 2—E, ES, ESS, SR, PT, IM, PR, A, AS, B, ON, ONS, PSL, PBY, OP1, P2; figure 2A on foldout 3—B2; and figure 3A on foldout 3—JP, AL.

Release, calling party disconnects first. When the calling party disconnects first, AUTOVON goes on-hook removing the ground on the E lead. Relay E releases. Next these things happen:

(1) E relay releases—E contacts 4 and 5 open the circuit to relay ES. E contacts 2 and 3 open the circuit to relay ESS.

(2) ESS relay releases—ESS relay serves no function at this time.

(3) ES relay releases—ES contacts 2 and 3 open the circuit to relay SR and put it on slow to release. SR times out and releases.

(4) SR relay releases—SR contacts 1 and 2 complete a circuit to relay P. SR contacts 4 and 5 open the circuit to relay PT and put it on slow to release. PT times out and releases.

(5) P relay operates—P contacts 9 and 11 complete a hold path for itself.

(6) PT relay releases—PT contacts 6 and 7 open the circuit to relay P. PT contacts 4 and 5 open the circuit to relay RV.

(7) RV relay releases—RV contacts 7T and 8T, 6B and 7B reverse the polarity of leads T and R. RV contacts 1T and 2T ground the sleeve of the cord supervisory circuit for SWBD disconnect supervision in conjunction with reverse battery.

Attendant removes answer cord. The attendant will remove the answer cord from JK1 upon recognizing disconnect supervision. This will open the loop to relay A and remove the ground from the K lead releasing relay JP. Here, watch for these actions:

(1) JP relay releases—JP contacts 6B and 7B open the circuit to relay OP1.

(2) OP1 relay releases—OP1 relay serves no function at this time.

(3) A relay releases—A contacts 7 and 8 open the circuit to relay AS. A contacts 2 and 3 open the circuit to relay B and put it on slow to release. B times out and releases. A contacts 1 and 2 complete a circuit to relay C. A contacts 4 and 5 change lead M from its off-hook condition to its on-hook condition.

(4) C relay operates—C relay serves no function at this time.

(5) B relay releases—B contacts 4 and 5 open the circuit to relay C and put it on slow to release. C times out and releases.

(6) C relay releases—C relay serves no function at this time.

(7) AS relay releases—AS contacts 4 and 5 open the circuit to relay ON and put it on slow to release. ON times out and releases.

(8) ON relay releases—ON contacts 10 and 11 open the circuit to relay ONS. ON contacts 8 and 9 open the circuit to relay PSL.

(9) PSL relay releases—PSL contacts 12B and 13B open the circuit to relay PR. PSL contacts 12B and 13B remove ground from lead HU.

(10) PR relay releases—PR contacts 9T and 10T extinguish the precedence busy lamp.

(11) ONS relay releases—ONS contacts 12T and 13T open the circuit to relay PBY. ONS contacts 12B and 13B open the circuit to relay P2. ONS contacts 4T and 5T open the circuit to relay AL. ONS contacts 4B and 5B open the ground on lead C. ONS contacts 10T and 11T open the circuit to relay B2 and put it on slow to release. B2 times out and releases.

(12) PBY relay releases—PBY contacts 12B and 13B extinguish the routine busy lamp. PBY contacts 10T and 11T open the circuit to relay IM.

(13) IM relay releases—IM relay serves no function at this time.

(14) P2 relay releases—P2 relay serves no function at this time.

(15) AL relay releases—AL relay serves no function at this time.

(16) B2 relay releases—B2 contacts 1 and 2 complete a homing circuit to RS1.

(17) RS1 magnet operates—RS1 steps self-interruptedly to its home position and opens its "ON" contacts, opening its homing circuit. The circuit is now at normal.

Called party disconnects first. When the called party disconnects first, the attendant will get disconnect supervision on her call cord. She will then remove the answer cord from the AUTOVON interface trunk. This opens the loop to relay A and removes ground from lead K releasing relay JP. Next these things take place:

(1) JP relay releases—JP contacts 6B and 7B open the circuit to relay OP1.

(2) OP1 relay releases—OP1 relay serves no function at this time.

(3) A relay releases—A contacts 7 and 8 open the circuit to relay AS. A contacts 2 and 3 open the circuit to relay B and put it on slow to release. B times out and releases. A contacts 1 and 2 complete a circuit to relay C. A contacts 4 and 5 change lead M from its off-hook condition to its on-hook condition, signaling AUTOVON of disconnect.

(4) AS relay releases—AS relay serves no function at this time.

(5) C relay operates—C relay serves no function at this time.

(6) B relay releases—B contacts 4 and 5 open the circuit to relay C and puts it on slow to release. C times out and releases. B contacts 1 and 2 complete a circuit to relay AR.

(7) AR relay operates—AR relay serves no function at this time.

AUTOVON disconnects. When AUTOVON goes on-hook, ground is removed from lead E releasing relay E. Watch here for these actions:

(1) E relay releases—E contacts 4 and 5 open the circuit to relay ES. E contacts 2 and 3 open the circuit to relay ESS.

(2) ESS relay releases—ESS relay serves no function at this time.

(3) ES relay releases—ES contacts 2 and 3 open the circuit to relay SR and put on slow to release. SR times out and releases.

(4) SR relay releases—SR contacts 1 and 2 complete a circuit to relay P. SR contacts 2 and 3 open the circuit to relay PT and put it on slow to release. PT times out and releases.

(5) P relay operates—P contacts 9 and 11 provide a hold path for itself.

(6) PT relay releases—PT contacts 6 and 7 open the circuit to relay P. PT contacts 4 and 5 open the circuit to relay ON and put it on slow to release. ON times out and releases. PT contacts 8 and 9 open the circuit to relay AR.

(7) AR relay releases—AR relay serves no function at this time.

(8) P relay releases—P relay serves no function at this time.

(9) ON relay releases—ON contacts 10 and 11 open the circuit to relay ONS. ON contacts 8 and 9 open the circuit to relay PSL.

(10) PSL relay releases—PSL contacts 12B and 13B open the circuit to relay PR. PSL contacts 12B and 13B remove ground from lead HU.

(11) PR relay releases—PR contacts 9T and 10T extinguish the precedence busy lamp.

(12) ONS relay releases—ONS contacts 12T and 13T open the circuit to relay PBY. ONS contacts 12B and 13B open the circuit to relay P2. ONS contacts 4T and 5T open the circuit to relay AL. ONS contacts 4B and 5B open the ground on lead C. ONS contacts 10T and 11T open the circuit to relay B2 and puts it on slow to release. B2 times out and releases.

(13) PBY relay releases—PBY contacts 12B and 13B extinguish the routine busy lamp. PBY contacts 10T and 11T open the circuit to relay IM.

(14) IM relay releases—IM relay serves no function at this time.

(15) P2 relay releases—P2 relay serves no function at this time.

(16) AL relay releases—AL relay serves no function at this time.

(17) B2 relay releases—B2 contacts 1 and 2 complete a homing circuit to RS1.

(18) RS1 magnet operates—RS1 steps self-interruptedly to its home position and opens its "ON" contacts opening its homing circuit. The circuit is now at normal.

Exercises (807):

Use foldouts 2 and 3 to complete the following.

1. What circuit action is responsible for returning precedence ringback tone to the calling party of a PNID call?

2. What circuit action occurs between 12 and 15 seconds after the precedence digit of an unanswered PNID call is pulsed?

3. What circuit actions occur as the direct result of the operator answering a diverted PNID call?

4. During a PNID call, what circuit action steps the central office equipment and what is responsible for that circuit action?

5. When is the condition of the M lead in the local trunk circuit changed for a diverted PNID call?

6. What contacts provide relay JP with ground for its hold path?

2-2. Troubleshooting Switchboard Applique Circuit and DTMF Keyset

Now that you are familiar with the operation of the trunk circuit and how it works with the switchboard applique circuit, let us see whether or not you can find specific trouble causes for trouble symptoms.

808. Given interface, switchboard applique, and DTMF keyset trouble symptoms and using foldouts 2, 3, and 4 as needed, identify the probable causes of trouble and the corrective action for each.

Remember the approach! You may be tired of reading about troubleshooting being a systematic approach used with a knowledge of circuit operations; but it is still true, and people still go about it in a haphazard manner. As you proceed through the problems, remember to use the approach and your knowledge of circuit operations to make troubleshooting as easy as possible and a satisfying experience.

Exercises (808):

Use foldouts 2, 3, and 4 in addition to the description of each trouble symptom to find the cause and state the corrective action for each in these exercises.

1. During seizure from the banks of the local selector, the M-lead condition changes from ground to open. What is the trouble and how would you correct it?

2. The incoming selector steps in response to the precedence digit of a PNID call. What is the trouble and how would you correct it?

3. On a precedence outgoing call from the switchboard, the routine busy lamp does not light. What is the trouble in the trunk circuit, shown in FOs 2 and 3, and how would you correct it? Contacts 12B and 13B of relay are not the cause of trouble.

4. The incoming selector fails to step during a PNID call. What is the most probable cause of trouble and how would you correct it?

5. The operator is not aware of a diverted PNID call, because the precedence answer lamp is not lit or flashing. What is the trouble and how would you correct it? (Use figure 3A on foldout 3.)

2-3. Foreign Applique Circuit

AUTOVON interface equipment at most oversea bases has foreign applique circuits. This is needed because these locations have telephone equipment that has been made by a foreign manufacturer.

In this section we cover only the applique circuit used to adapt the German manufactured Siemens RP-40 switching equipment, but an understanding of these circuits will provide you with principles necessary to work on most foreign applique circuits.

809. Using foldouts 2 and 5 and figure 2-3 as necessary, identify the actions that occur in the foreign applique circuit during an NID call and state the effects those actions have on associated circuits.

Before we start into the foreign applique circuit, you need your eyes open wide. The schematic diagram for the circuit is a detached contact-type schematic. Not only is it drawn to eliminate many close lines, but also the lines are all shorter and direct when compared with all of foldout 2. One other thing you need to know is how to interpret the symbols used; let us provide you with the necessary details right.

Symbols. Figures 2-3A and 2-3B shows the many symbols used, along with an explanation of each symbol. Since all of these symbols are individually explained in the figure, we will not repeat the explanations here. There are, however, a couple of things that should be explained further.

Contact numbering has always been a necessity in schematic reading and troubleshooting. Foldout 5, found in a separate enclosure, and figures 2-3A and 2-3B show contacts in several configurations, with only one contact numbered.

Contacts make to a higher number and break from a lower number. This means that if you see a set of make contacts with the number "5" beside them that contacts 5 and 6 of whatever relay it is make when the relay operates. Conversely, you should gather from seeing a set of break contacts with the number "5" beside them that contacts 4 and 5 break when the relay operates.

With this information and the use of figures 2-3A and 2-3B mastered, you are now ready to proceed through the applique circuit (foldout 5) and the trunk circuit (foldout 2) as an incoming call and an outgoing call are processed.

The applique circuit is located between the interface trunk circuit and the central office switching

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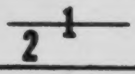
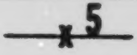
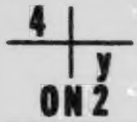
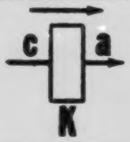
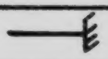
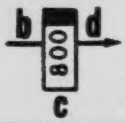
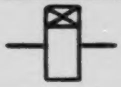
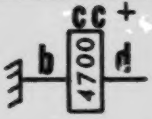
SYMBOL	EXPLANATION
r	DENOTES A SET OF BREAK CONTACTS
	DENOTES BREAK CONTACTS 1 AND 2 NOTE: BREAK CONTACTS ALWAYS BREAK FROM LOWER NUMBERED CONTACT
e	DENOTES A SET OF MAKE CONTACT
	DENOTES MAKE CONTACTS 5 AND 6 NOTE: MAKE CONTACTS ALWAYS MAKE TO HIGHER NUMBERED CONTACT
e X	"X" CONTACTS, MAKE FIRST
t	MAKE-BEFORE-BREAK CONTACT
s	BREAK-BEFORE-MAKE CONTACT
r° or s°	INDICATES TYPE OF ALLOYS USED IN CONTACTS
(r) or (e)	DENOTES A SET OF UNUSED CONTACTS
	THE Y INDICATES THAT THIS IS THE LAST CONTACT IN THE PILEUP AND THE LAST CONTACT TO OPERATE (BREAK CONTACTS IN THIS INSTANCE)
	THE ARROW INDICATES THAT THIS WINDING IS IN OPPOSITION, MAGNETICALLY, TO THE OTHER WINDING OF THE SAME RELAY. THIS SHOWS THE A–C WINDING OF RELAY K.
→	BATTERY
	GROUND
	SLOW TO RELEASE C RELAY. SHOWS THE b-d WINDING WITH THE d TERMINAL CONNECTED TO GROUND. THE b- WINDING HAS 800 OHMS RESISTANCE.
	SLOW TO OPERATE RELAY
	THE + SYMBOL NEXT TO THE RELAY IDENTIFIER INDICATES THAT THIS RELAY IS NORMALLY OPERATED.

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Figure 2-3A. Symbols.

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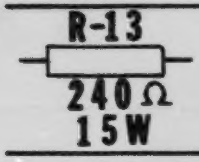
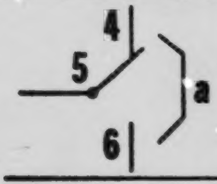
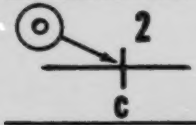
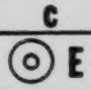
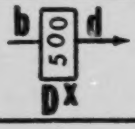
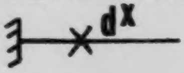
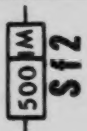
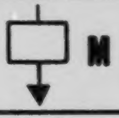
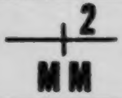
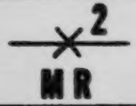
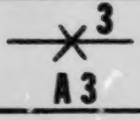
SYMBOL	EXPLANATION
	THIS IS RESISTOR R-13 ITS VALUE IS 240 OHMS AND IS RATED AT 15 WATTS. IF NO WATTAGE RATING IS SHOWN IT IS CONSIDERED TO BE 1 WATT.
	MAKE-BEFORE-BREAK CONTACTS OF RELAY a
	THE SYMBOL, POINTING TO BREAK CONTACTS 1 AND 2 OF RELAY C, INDICATES A SPECIAL ALLOY IS USED FOR THE CONTACTS. USED IN TRANSMISSION PATH ONLY.
	THIS POINT IN THE CIRCUIT IS CONNECTED TO THE CORRESPONDING POINT IN TRUNK CIRCUIT H-75650-A.
	THIS THE OPERATE WINDING FOR THE "X" CONTACTS  OF THIS RELAY
	THIS IS A 500 OHM IMPEDANCE COIL AND IT HAS NO CONTACTS
	ROTARY MAGNET FOR A ROTARY SWITCH
	ROTARY INTERRUPTER CONTACTS 1 AND 2. THESE CONTACTS BREAK WHEN THE ROTARY MAGNET OPERATES.
	ROTARY OFF-NORMAL SPRINGS 2 AND 3. THESE ARE MAKE CONTACTS.
	MAKE CONTACTS 3 AND 4 OF THE A3 RELAY.

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Figure 2-3B. Symbols.

equipment. In the following circuit descriptions, the relays, unless otherwise designated, will be in the foreign applique circuit.

NID Call. This is a call coming into the exchange from the AUTOVON switch. As shown in foldout 2, the action of the trunk is the same as that explained in Chapter 1 of this volume and will be touched on here only as needed to clarify these explanations.

Seizure. The trunk circuit closes a loop to relay A over terminals +L and −L; see coordinates A-6 and B-6 of foldout 5. This loop is closed to the applique circuit when contacts 6 and 7 of relay E in the trunk circuit make. The trunk circuit also causes the following to happen in the applique circuit:

It closes ON1 relay to ground via terminal S.

It opens a chain of contacts between terminals BS and C, causing CC to restore.

It lights the routine busy lamp on the switchboard.

NOTE: Relay CC is normally operated from battery in the idle associated trunk circuit via "BS" and K wiring options.

These things then occur:

(1) A relay operates—contacts 5 and 6 close a path to operate relay BJ.

(2) CC relay releases—contacts 1 and 2 open, removing battery from lead C2 to prevent NOD call access from outgoing selector banks.

(3) ON1 relay operates—contacts 5 and 6 close a path to operate relay ON2.

(4) BJ relay operates—contacts 29 and 30 provide relay BJ with a hold path; contacts 10 and 11 ground lead C1 to the incoming selector; and contacts 6 and 7 ground wipers A, B, and C of rotary switch M.

(5) ON2 relay operates—it performs no function at this time.

Outpulsing to incoming selector. When the E relay in the trunk circuit starts pulsing in response to the changing condition of the E lead, its 6 and 7 contacts open and close the circuit to the A relay, in the applique circuit, over the +L and −L leads. In response to the first impulse break relay A releases. These things happen then:

(1) A relay releases—contacts 1 and 2 place ground on the A1 lead to the incoming selector and contacts 3 and 4 close a path to rotary magnet M and relay C.

(2) C relay operates—contacts 8 and 9 place 800 ohm resistance battery on lead b1 to the incoming selector. This splits the pulsing by using battery and ground pulsing for the incoming selector instead of loop pulsing. Contacts 5 and 6 remove ground from wipers A and B of rotary magnet M.

Impulse make. During impulse make, contacts 6 and 7 of relay E in the trunk circuit close. This closes the loop across +L and −L leads to relay A. Relay A reoperates. These things occur:

(1) A relay operates—contacts 1 and 2 remove ground from the A1 lead; and contacts 3 and 4 open the path to the C relay (slow-to-release), which does not release until dial pause and the rotary magnet M steps one step.

(2) Rotary magnet steps—cam springs MR (A-5 on schematic) go off-normal, but do nothing else at this time.

Impulse break, second. During the second impulse break, the same events occur. The second digit is outpulsed to the incoming selector, the rotary magnet M operates, and the C relay is reenergized to keep it from releasing.

Impulse make, second. The loop across the L and -L leads opens, closing the circuit to relay A. These things occur:

(1) A relay operates—contacts 1 and 2 remove ground from terminal A1 to the incoming selector; and contacts 3 and 4 open the path to the rotary switch M, causing it to step to the second set of contacts and place relay C on slow-to-release.

(2) Rotary switch steps to second contact—the ground on wiper C closes a path to operate relay D to its "X" contacts.

(3) D relay operates to its "X" contacts—contacts 1 and 2 close a hold path to ground through contacts 6 and 7 of relay BJ to ground.

Dial pause. During dial pause relay C times out and releases. Then these actions take place:

(1) C relay releases—contacts 8 and 9 break removing battery from the b1 lead to the incoming selector. Contacts 7 and 8 close applying ground through relay S, to the b1 lead. Contacts 5 and 6 close ground to wipers A and B of the rotary switch and remove the shunt from the AC winding of relay D; allowing it to operate fully.

(2) D relay operates fully—contacts 3 and 4 open preventing the rotary switch from stepping further.

During the next and subsequent digits, the same circuit actions occur, except that relay D remains operated, thereby preventing the rotary switch from further stepping.

After the last digit is dialed, the connector tests the line. If the line is busy, a busy tone is sent back to the calling party from the connector through the applique and trunk circuits.

Called line idle. If the called party's line is idle, the connector rings the line. When the called party answers, battery through a 750-ohm inductance coil in the connector is placed in the b1 lead operating the S relay (B-2 on print).

Thereafter, S relay operates—contacts 6 and 7 place the b-d or negative winding to the A1 lead; and contacts 2 and 3 place capacitors C2 and C3 in parallel, increasing the capacitance to microfarad. Contacts 8 and 10, and 11 and 13 reverse the battery to the trunk circuit, causing relay SP in the trunk circuit to operate.

Called party hangs up first. When the called party hangs up, 750 ohm ground through an inductance coil in the connector is placed on the A1 lead, causing relay A2 to operate. These actions occur:

(1) A2 relay operatees—This reverses the polarity to the trunk circuit, releasing relay SP.

> NOTE: After a few seconds, the trunk circuit removes ground from terminals S and SH, causing relays ON1 and BJ to release. The trunk circuit also opens the path of relay A and closes battery from the BS terminal to terminal C, causing relay CC to reoperate.

(2) BJ relay releases—contacts 10 and 11 open, removing ground from the C1 lead to the incoming selector, which causes the selector to release. Contacts 6 and 7 open the path of relay D, releasing it, and contacts 5 and 6 close a path to the rotary switch M, causing it to step to its home position.

(3) ON1 relay releases—contacts 5 and 6 break opening the path of relay ON2, which remains operated until capacitor C1 discharges. Contacts 1 and 2 close a path to relay ON3, causing it to operate.

(4) Relay CC operates, relays A and D release, and the incoming selector restores, opening the S and A2 leads.

(5) ON3 relay operates—contacts 8 and 9 and 10 and 11 close paths to the routine and precedence busy lamps on the switchboard. Contacts 1 and 2 and 3 and 4 open, preventing premature seizure from the switchboard. Contacts 5 and 6 break, removing battery from leads C2 and C3; this prevents premature seizure by an NOD call.

(6) S and A2 relays release and the rotary switch is at home—the rotary switch cam switch contacts MR (2 and 3) open the path to the rotary magnet.

(7) ON2 relay releases—when capacitor C1 has discharged, relay ON2 releases. Contacts 1 and 2 open the path to relay ON3, releasing it.

(8) ON3 relay releases—contacts 7 and 8 open, extinguishing the routine busy lamp and contacts 10 and 11 open, extinguishing the precedence busy lamp. Contacts 1 and 2, 3 and 4, and 5 and 6 make, preparing the circuit for another call.

Calling party hangs up first. (Relays A, BJ, D, ON1, ON2, S are operated.) Nothing happens, because SP in the trunk circuit is held through A, which in turn, is held through SP. When the called party hangs up too, the ensuing sequences are same as those cited above.

Exercises (809):

Use foldouts 2 and 5 and figures 2-3A and 2-3B as required to answer the following.

1. What contacts make to operate relay ON3?

2. What circuit action makes the ON2 relay slow-to-release?

3. What prevents premature seizure for an NOD call during release from an NID call?

4. What prevents the operator from initiating a routine call prior to complete release of the circuit, shown in foldout 5, from another call?

5. What happens in the applique circuit, shown in foldout 5, when the called party answers an NID call?

6. What circuit action is responsible for the D relay, in the applique circuit, shown in foldout 5, operating fully?

810. Using foldout 5 as necessary, distinguish among the actions that occur in the foreign applique circuit during an NOD call and present the effect those actions have on associated equipment.

NOD Call. With your new-found expertise in reading a detached print schematic, you have probably found that it beats reading prints that contain many more lines. Let us now take a look at an NOD call processed through to foreign applique circuit.

Seizure. Low resistance ground to lead C2 from the outgoing selector bank via the 60-ohm winding of relay P of the local first selector causes relay N to operate. These actions occur:

(1) N relay operates—contacts 5 and 6 close a hold path to lead C2. Contacts 9 and 10 break to improve inhibited test conditions. Contacts 1 and 2 make (D-5) closing a no resistance loop across the + and − (RA and TA) (D and E-6) to the trunk circuit, operating the A relay in the trunk circuit.

> NOTE: The trunk circuit grounds terminals H6 and 5, causing relays BB and ON1 to operate and removes battery from lead C causing relay CC to release.

(2) CC relay releases and relay BB operates—no functions are accomplished by these relays at this time.

(3) ON1 relay operates—contacts 5 and 6 close a path to relay ON2, operating it. Contacts 3 and 4 open the short circuit across inductance coil SF2. SF 2 was shorted initially, to speed up the operation of relay A in the trunk circuit. Relay ON2 operates, but does nothing at this time.

Dialing, impulse break. During impulse break ground is placed on lead A2, operating the A3 relay. This then occurs:

(1) A3 relay operates—contacts 1 and 2 break, opening the loop that operated the A relay in the trunk circuit, causing it to release. Contacts 3 and 4 close a path to relay C1, causing it to operate.

(2) C1 relay releases—contacts 1 and 2 make, improving the pulsing path.

Impulse make. Ground is removed from the A2 lead and relay A3 releases. These actions take place:

(1) A3 relay releases—contacts 1 and 2 make, reclosing the loop to the trunk circuit, causing the A relay in the trunk circuit to reoperate. Contacts 3 and 4 open, causing relay C1 to release.

(2) C1 relay releases—closing a no-resistance path through contacts 3 and 4, 5 and 6, and 7 and 8 and splits the pulsing path backwards through contacts 1 and 2.

> NOTE: The same series of events occurs for the remainder of the impulse breaks and makes and dial pause.

Called party answers. When the called party answers, relays E, ES, ES5, and RV in the trunk circuit operate and ground is removed from the SP5 terminal allowing relay S2 to operate.

These things happen: S2 relay operates—contacts 5 and 6 place capacitors C6 and C7 in parallel; increasing the capacitance to 8 microfarads in the transmission path. Contacts 1 and 2 break, opening the A2 lead, and contacts 7 and 8 make doing to the other side of the transmission path the same thing contacts 5 and 6 did.

Calling party hangs up first. When the calling party hangs up ground is removed from lead C2, causing relay N to release. These actions take place:

(1) N relay releases—contacts 1 and 2 break, opening the loop to the A relay in the trunk circuit. Contacts 3 and 4 break, opening the path to relay S2, and it releases.

(2) Trunk circuit removes ground from the HG terminal—this causes relay BB to release. The trunk circuit, after determining that this is a release and not a request for DSA, removes ground from lead 5, releasing relay ON1 and put battery on lead C to reoperate relay CC.

(3) ON1 relay releases—this puts the ON2 relay on slow-to-release and closes a path to operate relay ON3.

(4) ON3 relay operates—this lights the routine and precedence busy lamps and opens other circuits to prevent premature equipment seizure.

(5) ON2 relay releases--this happens when capacitor C1 discharges. Contacts 1 and 2 break, opening the path to relay ON3, causing it to release.

(6) ON3 relay releases--contacts 8 and 9 and 10 and 11 break, extinguishing the routine and precedence busy lamps. Contacts 1 and 2, 3 and 4, and 5 and 6 make preparing the circuit for another call.

Called party hangs up first. (Relays BB, N, ON1, ON2, S2 are operated.) Ground is put on terminal SPS which short circuits the S2 relay. When the caller hangs up too, ground is removed from terminal C2 and relay N restores.

Exercises (810):

Use foldout 5 to complete the following.

1. What happens in the trunk circuit when a local first selector seizes it?

2. During an NOD call, what relay contacts transmit the dial pulses to the trunk circuit?

3. During an NOD call, what marks the circuit busy to other local selectors?

4. During an NOD call, what action occurs in the applique circuit when the called party answers?

2-4. Troubleshooting the Foreign Applique Circuit

Here you are again; you have just found out how it all works and we are about to put troubles into it all. But remember, the payoff on understanding circuit operation is in correcting troubles. As long as the equipment is working, we don't need to know how it operates.

811. Given foreign applique circuit trouble symptoms, using foldout 5 as needed, specify the probable causes of trouble and give the corrective action for each.

You have studied operation of foreign applique circuits both here and in technical school. We have also covered the logical approach to troubleshooting previously. So, without further ado, let's proceed to the exercises and see how well you have mastered the theory of operation.

Exercises (811):

Use foldout 5 to identify the probable cause of trouble for the following symptoms; also, state the corrective action for each.

1. During release from an NID call, the rotary switch fails to step to the home position.

2. During an NOD call, the trunk circuit does not respond to the digits dialed.

3. During an NOD call, the circuit is accessed by another local selector.

4. During the release of an NID call the circuit is accessed by a local selector.

2-5. SF signaling Set and VF Line Amplifier

We explained earlier what the SF signaling set and VF line amplifier do and why they are in the circuit. Now you need a basic idea of how they work. You can't test, adjust, or fix equipment intelligently if you do not have an idea of how it works.

812. Using foldout 7, identify the actions that occur in the SF signaling set and specify the effects those actions have on associated equipment.

SF Signaling Set. The SF signaling set is composed of two largely independent sections, the transmit section and the receive section; each section is discussed separately and includes subscriber on-hook, off-hook, and dial pulse conditions. There are two relays designated K1 in the SF signaling set (foldout 6). One is in the oscillator unit and the other is in the control unit. In the descriptions which follow, the particular K1 relay covered is identified as oscillator unit relay K1 or control unit relay K1.

Transmit section. With the local subscriber in the on-hook condition, the M lead is at ground, the amplitude control circuit consisting of transistor Q2 is off, and the bias on diode CR1 is set by resistors R8 through R12, which act as a voltage divider. Under these conditions, transistor Q1 turns on and generates a 2,600-Hz tone at a low level (-36 dB) that is coupled through the windings of transformer T1. The amplitude of oscillation of Q1 is controlled by the amount of bias on diode CR1. Transistor Q1 is a positive feedback amplifier in which a portion of the output from the collector is coupled back to the emitter through T1.

With the M lead at ground, and the N lead grounded through the operated contacts of control unit relay K1, the transmission cut circuit is activated. Transistor Q3 in the transmission cut circuit conducts, energizing oscillator unit relay K1. Even when the N lead alternately changes from ground to open during far-end dial pulsing, oscillator unit relay K1 remains operated through capacitor C10, which discharges during the momentary open states of the N lead. The operated contacts of oscillator unit relay K1 place a short circuit across the voice-frequency input terminals and remove the short across resistor R19, placing a 600-ohm termination across the transmit line terminals.

When the local subscriber goes off-hook -48 volts is applied to the M lead, forward biasing diode CR1. This turns off transistor Q1 and removes the 2,600-Hz signal from the line. In addition, the steady -48 volts on the M lead causes oscillator unit relay K1 to be deenergized, regardless of the state of the N lead. Under these conditions, the transmit line is connected directly to the voice-frequency input terminals.

When dial pulsing is initiated by the local subscriber, the M lead is alternately placed at 0 and -48 volts DC and the 2,600-Hz tone oscillator Q1 is alternately turned on and off. The -48 volt DC and ground pulses on the M lead also causes transistor Q2 of the oscillator amplitude control circuit to conduct through -48 volts DC in one state, and slow discharging capacitor C3 in the other. When the M lead returns to ground, capacitor C3 discharges through resistors R14 and R13 and transistor Q2. The C3 discharge current holds transistor Q2 on to increase the reverse bias voltage on diode CR1. This higher reverse bias causes tone oscillator transistor Q1 to transmit a 2,600-Hz tone to the far end at a higher level (-24 dB) during the pulsed on-hook state than in the steady on-hook state.

To enable the 2,600-Hz tone oscillator to operate quickly on the ground pulse of the M lead, the positive-going transient at the collector of transistor Q2 is coupled to the emitter of 2,600-Hz tone oscillator transistor Q1. Oscillator unit relay K1 remains energized during dial pulsing and keeps the transmit input terminals terminated to 600 ohms and the transmit output terminals shorted.

During local subscriber dial pulsing, oscillator unit relay K1 is kept energized by the diode-capacitor network CR4, CR3, C10, and C9. When the M lead goes to -48 volts, C10 charges through CR4, while C9 charges through diodes CR4, CR5, and the coil of oscillator unit relay K1, energizing K1. With the M lead at ground, C9 discharges through CR3, while C10 discharges through the coil of oscillator unit relay K1 and CR3, keeping K1 energized.

Receive section. With the distant subscriber on-hook, incoming 2,600-Hz signals are coupled through input transformer T3 and enter an input balance network. the input balance network is a resistance hybrid circuit consisting of resistors R30, R31, R32, and R33. The signal is then coupled to a filter network consisting of three tuned circuits, each tuned to 2,600 Hz. One circuit, inductor L1 and capacitor C5, acts as an antiresonant parallel network and is in series with series-resonant inductor-capacitor network L2 and C4. Voltages are developed for only a narrowband of frequencies around the 2,600-Hz antiresonant frequency. The third circuit is another antiresonant parallel inductor-capacitor network, L3 and C6. This network and the series-resonant network L2 and C4 constitute a 2,600-Hz rejection filter. The 2,600-Hz narrow bandpass filter, L1 and C5, passes the signaling tone to the three-stage signal tone amplifier.

The signal tone amplifier consists of transistors Q1, Q2, and Q3 connected in a common emitter arrangement. The output of Q3 is rectified by diodes CR2 and CR3, and the resultant negative DC voltage is applied to the base of transistor Q7 of the first threshold detector.

The output of the 2,600-Hz rejection filter, which passes other voice-frequency signals, is coupled through capacitor C3 to a two-stage guard amplifier consisting of common emitter stages of transistors Q4 and Q5. The output of Q5 is rectified by diodes CR7 and CR8 to produce a positive DC output, which is fed through resistor R20 and diode CR9 to the base of transistor Q7 of the first threshold detector.

To keep the output of the guard amplifier (transistor Q5) from producing a false no-signal-tone indication when the 2,600-Hz tone is present, the guard amplifier is disabled by an amplifier gain control circuit (transistor Q6) which, at the same time, increases the gain of the signal tone amplifier. Under these conditions only, the negative dc output from the signal tone amplifier (transistor Q3) is applied to the base of transistor Q7.

The first threshold detector, consisting of transistors Q7 and Q8, forms a Schmitt trigger circuit. When the base of Q7 is negative, Q7 conducts and Q8 is off. The potential of collector Q7 is near ground, and the signal selector circuit transistor Q4 in the oscillator unit cannot conduct. As a result, oscillator unit relay K2 is deenergized, and its contacts connect the 2,600-Hz rejection filter in series with the input to receive amplifier transistors Q5 and Q6. All voice frequencies, except the 2,600-Hz signal tone, are, therefore, amplified. The two-stage receive amplifier is a conventional feedback circuit with a gain adjustment of approximately −8 to +12 dB, provided by the RCV LEVEL control (R24). The output signal from transistor Q6 is applied through output transformer T2 to the local terminal switching equipment.

The second threshold detector consists of a driver stage, transistor Q9, and a Schmitt trigger, transistors Q10 and Q11. With signal tone being received from the distant terminal, the driver stage is conducting. With Q9 on, the negative potential at its collector causes Q10 of the Schmitt trigger to conduct and Q11 to remain off, thus, with steady signaling tone present, there is no output from the second threshold detector. Therefore, control unit relay K1 remains denergized. With control unit relay K1 deenergized, the E lead remains open, and ground on the N lead is applied to amplifier gain control circuit (Q6) and to the transmission cut circuit (transistor Q3). Transistor Q6 turns on, forward biasing diode CR1, which effectively parallels resistor R5 with resistor R4 to increase the gain of the transistor Q2 signal tone amplifier. Transistor Q6 conducting causes transistor Q4 to disable guard amplifier transistor Q5. The ground, which goes through control unit relay K1 contacts over the N lead to the transmission cut circuit, causes oscillator unit relay K1 to operate. Operation of oscillator unit relay K1 shorts the transmit input terminals and terminates the transmit output terminals to 600 ohms.

With the distant subscriber off-hook, no signaling tone is received from the distant end, and there is no output from signal tone amplifier transistor Q3. This results in an absence of negative voltage at the base of transistor Q7, causing the first threshold detector to trigger to its off state (transistors Q7 off, Q8 on). With the first threshold detector in its off state, the Q8 collector potential causes the input to the inverter in the pulse modifying network to change from a logic 0 (ground) to a logic 1 (−48 volts). At the same time the potential of the collector of Q7 increases, causing transistor Q4 in the oscillator unit to conduct. Relay K2 operates, and the input of the receive amplifier, which comes directly from the input balance network, is unfiltered. The output of the first threshold detector is applied through the pulse modifying network to the second threshold detector. The presence of a signal at the base of driver stage transistor Q9 causes the second threshold detector to trigger to its off state (transistors Q10 off, Q11 on). With Q11 conducting, control unit relay K1 is energized.

With control unit relay K1 energized, ground is applied to the E lead. The N lead ground that was applied to amplifier gain control circuit (transistor Q6) and the transmission cut circuit (transistor Q3) is removed. When ground is removed from Q6, it stops conducting, causing guard amplifier transistors Q4 and Q5 to conduct. The rectified output from Q5 can now get through to the base of transistor Q7. Since transistor Q6 is not conducting, it no longer causes a decrease in the emitter resistance of transistor Q2 in the signal tone amplifier, thereby decreasing the gain of the signal tone amplifier. Thus, a 2,600-Hz signal that is part of voice frequencies and enters the signal tone amplifier is not likely to override the guard amplifier output from Q5 and falsely trigger the first threshold detector to its on state (Q7 on).

With dial pulses being generated by the distant subscriber, the incoming signal at input transformer T3 consists of intermittent 2,600-Hz tone bursts corresponding to the dial pulse rate. When the signaling tone is present, the rectified output of the signal tone amplifier (transistor Q3) triggers the first threshold detector to its on state transistors Q7 on, Q8 off); and, when tone is absent, the first threshold detector returns to its off state (Q7 off, Q8 on). The first threshold detector thus changes state in accordance with the received dial pulses.

The output of the first threshold detector is passed through the pulse modifying network to provide for variable pulse delay. The pulse modifying network consists of an integrated circuit made up of an inverter (NAND gate with one active input) and two additional NAND gates, each of which has two active inputs. The collector of transistor Q8 feeds the first NAND gate, which acts as an inverter. Capacitor C15, which is parallel with resistor R50, provides approximately 10 milliseconds delay in the inverter output. The inverter feeds the second NAND gate through the time constant of resistance-capacitance network R29, R30, R31, and C10, which provides another signal delay of 10 milliseconds for only those inverter output changes that are going positive. The output of the second NAND gate is applied to the third NAND gate through R34, R35, R37, and C11. Variable pulse delay is accomplished by adjusting R34, the BIAS ADJ control, which effectively varies the percent break of control unit relay K1. The output of the third NAND gate operates the second threshold detector driver transistor Q9 through resistor R39.

While dial pulses are being received, the amplifier gain control circuit (transistor Q6) must be kept off to allow full amplification of the signal tone amplifier when 2,600-Hz signal tones are present. This is done as follows: as soon as the signaling tone is interrupted, control unit relay K1 is energized, diode CR4 in the amplifier gain control circuit is forward biased by -48 volts, and capacitor C5 charges rapidly through CR4. When the signal tone returns and control unit relay K1 is deenergized, CR4 is back biased by the ground applied on the N lead, and Q6 is held off by the negative potential from C5 applied to its base. Capacitor C5 discharges slowly through resistor R17, and the time constant of the circuit is such that Q6 will be kept off for 300 milliseconds after the signal tone returns. If the signal tone is again interrupted before the end of this period, the charge on C5 is replenished to keep Q6 off for another 300 milliseconds after control unit relay K1 is deenergized.

Exercises (812):

Use foldout 7 and the text to answer the following questions.

1. With the trunk circuit idle, what relay is operated in the SF unit?

2. What happens in the SF unit when the trunk circuit is seized for an NOD call?

3. When 2,600-Hz tone stops being received by the local SF (control unit) unit, what relay operates and how does it affect the trunk circuit?

4. Which diode, in the SF unit (osc unit) is in the path that operates relay K1?

813. Using foldout 7, identify the functions that occur in the VF line amplifier and state the effects the actions have on associated equipment.

VF Line Amplifier. Since the VF line amplifier consists of two identical circuits (foldout 7)—a transmit amplifier circuit and a receive amplifier circuit—only the receive amplifier circuit is discussed. The receive signal from the four-wire line facility enters the primary of input transformer T1. The secondary of transformer T1 is strapped for 600-ohm line impedance. A receive line (RCV LINE) jack circuit across the primary of transformer T1 allows for test equipment to be inserted which breaks the circuit to the amplifier and looks back toward the line through the transformer. The signal then enters an impedance network consisting of potentiometer R2 and resistors R1 and R3. An equalizing network, consisting of potentiometer R4 and capacitor C1, follows. This network tends to form a constant impedance so that, regardless of the position of R2 and R4, the input impedance stays nearly the same. Capacitor C2, which follows the equalizing network, isolates the bias voltage on transistor Q1 from the input networks. Resistors R5 and R6 provide the necessary bias for operating input transistor Q1. Resistor R8 and capacitor C3 form a bypassed emitter circuit to allow full gain and have a high degree of destabilization. Resistor R7 establishes the gain of input transistor Q1. Inductor L1 and capacitor C15 form a low-pass filter network which drectly couples the collector of Q1 to the base of transistor Q2, which is an emitter follower. The low-pass filter network restricts the bandwidth to that of the normal voice band. The output at the emitter of Q2 is coupled into the base of transistor Q3 via capacitor C4. Resistors R11 and R12 form a bias network for Q3 in the power output stage.

Power output stage Q3 is a silicon power transistor, which allows full power output even at high temperatures. Resistor R13 is the emitter resistor of Q3 and is partially bypassed by capacitor C5. Resistor R15, in series with C5, sets the gain of Q3 to the proper value. The output of Q3 is R-C coupled to

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output transformer T2, and fed back to input transistor Q1 via feedback resistor R16. This stabilizes the gain and impedance over a wide temperature range. The secondary winding of T2, also strapped for 600-ohm line impedance, is connected to a jack circuit. This allows the output of the amplifier to be tested and disconnects it from output transformer T2. Resistor R33 and capacitor C13 form a decoupling network, which provides necessary transient and noise isolation from the battery supply. Resistor R35 and R36 are dropping resistors, which provide -24-volt DC operating potentials from the -48-volt DC battery supply.

Exercises (813):

1. The VF line amplifier is composed of how many circuits?

2. What does the impedance network, consisting of potentiometer R2 and resistors R1 and R3, do in the VF line amplifier?

3. What is the function of the low-pass filter network in the VF line amplifier?

2-6. Troubleshooting the SF Signaling Set and VF Line Amplifier

While you won't be doing much in the way of repairing or troubleshooting the SF units and VF line amplifiers, you do have to be able to determine when they are the cause of circuit trouble.

814. Given a series of situations involving SF signaling set and VF line amplifier trouble symptoms and using foldouts 6 and 7 as necessary, identify the probable causes of trouble and provide the corrective action required for each such situation.

To this point you have received an admittedly tightly packed amount of information about both the SF signaling set and the VF line amplifier. Along with this you have been provided with text-related schematic diagrams found on foldouts 6 and 7 (bound in a separate enclosure). So you have the facts. You should, and likely do, know what to do with this material when, as is inevitable, you are called on to troubleshoot the SF signaling set and VR line amplifier. But *do* you—*can* you *really* successfully and consistently troubleshoot these items? Let's see.

What follows is a series of hypothetical situations revolving around this signaling set and this line amplifier:

- You find relay K1 of the SF unit (osc unit) is not operated. The trunk is completely idle.
- Called to investigate, you discover that there is no idle termination on the XMIT side of the line.
- A member of your unit reports that the VF line amplifier is not working. He says its because -48 volts battery, though connected, is not getting into the amplifier.

Exercises (814):

Consult foldouts 6 and 7 as necessary, to locate the probable causes of trouble in each of the following situations, providing the correct action, and for item 2 the reason, to resolve the problems shown.

1. What problem exists when, with the trunk completely idle, relay K1 of the SF unit (osc unit) is not operated?

2. Give both the reason and the proper action to take when no idle line termination exists on the XMIT side of the line with relay K1 (osc unit) of the SF unit operated.

3. Identify the trouble and tell how to correct it when the VF line amplifier is not working, because -48 volts battery, though connected, is not getting into the amplifier.

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CHAPTER 3

Interface Maintenance

IN THIS CHAPTER you are going to spend your time studying about maintenance and testing of equipment and circuits in your office used by the AUTOVON switch personnel to test the lines. You will also look at some of the test equipment you use and at some of the test procedures used for testing and aligning interface equipment in the dial central office.

3-1. Special Test Circuits

The previous chapters in this volume covered the principles of operation for the equipment required to interface the PABX with AUTOVON. This section explains the circuit operation of the special test circuits used by AUTOVON switch personnel to make transmission tests on the interface equipment trunks or access lines to prevent abnormal operation and to insure rapid restoral of service if an access line fails.

815. Using figure 3-1 and foldouts 8, 9, and 10 as needed, give the purpose or use of specified AUTOVON interface test circuits and identify noise and balance test line circuits, connector access number, and the terminations provided by the end office loop around test circuit (use foldout 1, too, if necessary).

Test Circuit Functions. Although your office does not use the special test circuits, they are located in your office, and you are expected to maintain them. Three circuits are provided to permit AUTOVON switch personnel to make tests on the interface trunks and access lines without bothering central office people.

Noise and balance test line circuit. This circuit (shown in foldout 8, found in a separate enclosure) provides balanced line termination for noise, balance (return loss and singing test), and transmission measurement tests performed from the AUTOVON switch. Singing is an undesired self-sustained oscillation existing in a transmission system.

Access to the noise and balance test line circuit is obtained by dialing the required test number at the AUTOVON switch. The access number assigned to the test circuit will usually end with a connector access number of 41, as shown in foldout 1. After the connector switches through, the test circuit returns 10 seconds of off-hook supervision (open circuit, short removed from R4). The circuit also provides 900-ohm 2-microfarad line termination to AUTOVON.

Reverse battery test line circuit. This circuit (shown in foldout 9, found in a separate enclosure) provides nonsynchronous (off-hook and on-hook) supervisory signals to the PABX connector for testing the supervisory functions of the PABX trunk circuits and interface equipment. The supervisory signals consist of a 1,000-ohm idle line termination for off-hook, and an open circuit line termination for on-hook. The connector repeats this off-hook/on-hook supervision to the PABX trunk circuit causing the SF signaling unit to transmit the supervision to AUTOVON via pulsing of the 2,600-Hz SF tone.

Access to the reverse battery test line circuit is obtained by dialing the required test number at the AUTOVON switch. The access number assigned to this test circuit will usually end with a connector access number of 31, as shown in foldout 1. After being accessed, the test circuit returns a series of supervisory signals followed by a continuous on-hook supervisory signal of 2 seconds duration and an off-hook supervisory signal of 5½ seconds duration.

End office loop around test circuit. This circuit (shown in foldout 10, found in a separate inclosure) provides a means for making stability and loop around tests. It enables one maintenance technician to make one-way and two-way transmission loss measurement tests on four-wire PABX access lines without manual assistance from the PABX. Access to this circuit is obtained by dialing the required test number at the AUTOVON switch. The access numbers assigned to the test circuits usually end with a connector access number of 21 for connector terminal No. 1 and 22 for connector terminal No. 2 (refer to foldout 1).

Figure 3-1 shows the various tests performed by the AUTOVON switch technician. To make the stability test, shown in figure 3-1,a, the technician must access connector terminal No. 1. Upon access, the test circuit returns 10 seconds of open circuit line termination with 1 second of 900-ohm 2-microfarad line termination; followed by 10 seconds of short-circuit line termination; followed by 900-ohm 2-microfarad

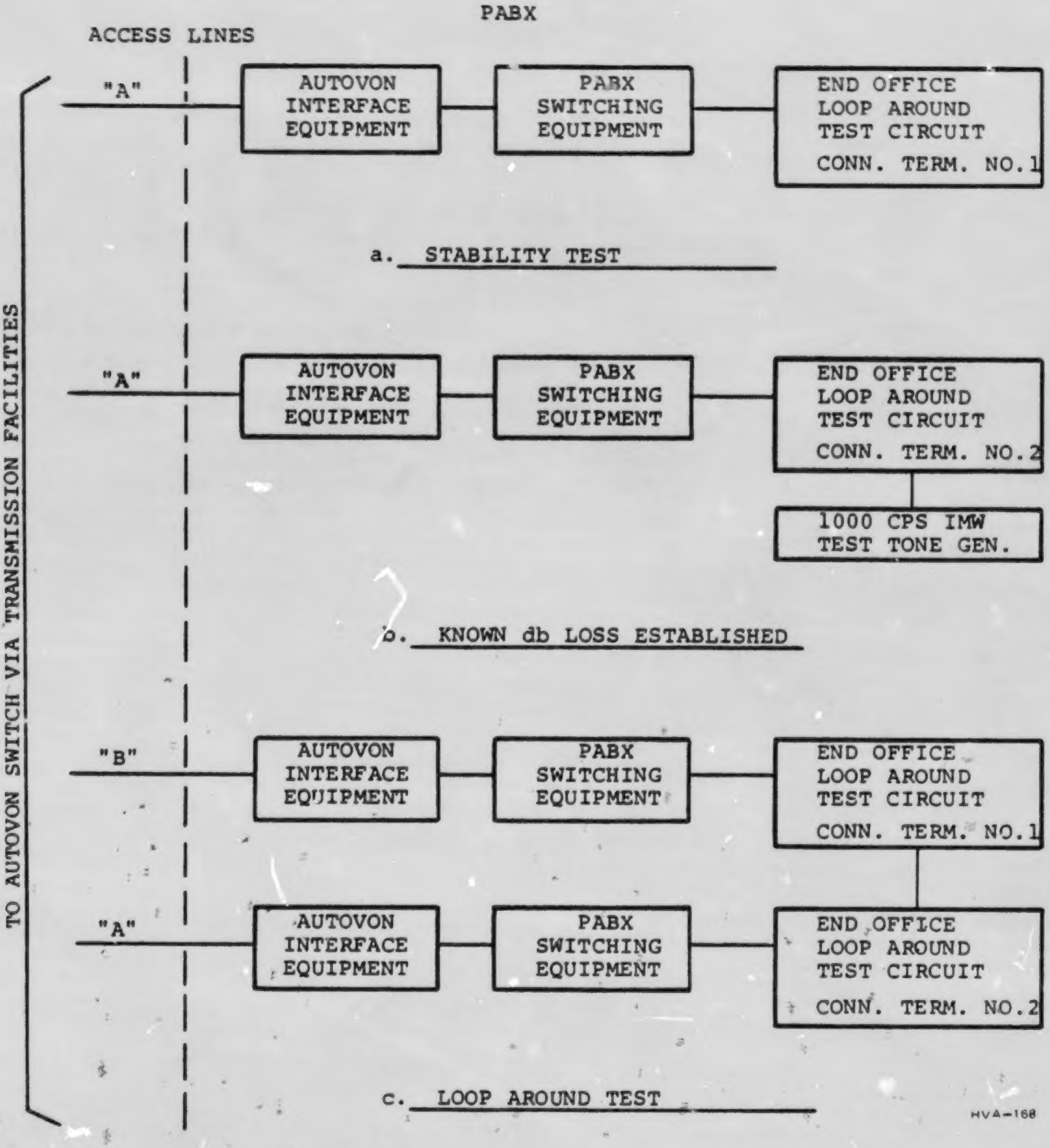
PABX
ACCESS LINES
TO AUTOVON SWITCH VIA TRANSMISSION FACILITIES
"A"
AUTOVON INTERFACE EQUIPMENT
PABX SWITCHING EQUIPMENT
END OFFICE LOOP AROUND TEST CIRCUIT CONN. TERM. NO.1
a. STABILITY TEST
"A"
AUTOVON INTERFACE EQUIPMENT
PABX SWITCHING EQUIPMENT
END OFFICE LOOP AROUND TEST CIRCUIT CONN. TERM. NO.2
1000 CPS IMW TEST TONE GEN.
b. KNOWN db LOSS ESTABLISHED
"B"
AUTOVON INTERFACE EQUIPMENT
PABX SWITCHING EQUIPMENT
END OFFICE LOOP AROUND TEST CIRCUIT CONN. TERM. NO.1
"A"
AUTOVON INTERFACE EQUIPMENT
PABX SWITCHING EQUIPMENT
END OFFICE LOOP AROUND TEST CIRCUIT CONN. TERM. NO.2
c. LOOP AROUND TEST
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Figure 3-1. PABX tests.

line termination. The circuit will remain with this 900-ohm 2-microfarad line termination as long as the connection is held.

For the technician to use the results of a loop around test, it is necessary for him to first establish the dB loss of an access line. To do this the technician must access connector terminal No. 2, shown in figure 3-1,b. Upon seizure of connector terminal No. 2, a 1,000-Hz test tone at 0 dBm is received from the test tone generator for 10 seconds, followed by 1 second of 900-ohm 16-microfarad line termination. These 10 seconds of 1,000-Hz test tone and 1 second of 900-ohm, 16-microfarad line termination are repeated as long as the circuit is held. The technician can measure the dB loss of the test tone with a VTVM to establish the dB loss of a particular access line. The technician would now release the connector because it is necessary to seize connector terminal No. 1 prior to connector terminal No. 2 to perform the loop around test.

The technician can now make a stability test and loop around test of the other access lines, shown in figure 3-1,c. He would access connector terminal No. 1 with the next access line and complete a stability test. He would hold this circuit and access connector terminal No. 2 with the access line of the known dB loss. He can now use the loop around test to measure the dB loss of the loop. By subtracting the known dB loss from the loop dB loss, he would arrive at the dB loss of the second access line.

Example:

Loop dB loss of access lines "A" and "B"	-4 dB
Known dB loss of access line "A"	
dB loss of access line "B"	-2 dB
Loop dB loss of access lines "A" and "C"	-9 dB
Known dB loss of access line "A"	-2 dB
dB loss of access line "C"	-7 dB

From these results, the technician would identify that access line "C" has transmission problems and would start corrective action to restore the circuit to working order.

Rotary switches. The type 44 rotary switch is installed in each one of the special test circuits. This rotary switch is different from the rotary switches that you have studied previously in the Telephone Switching Equipment Repairman Course.

The type 44 rotary switches are small, lightweight, and fast-stepping. The rotary switch steps approximately 65 steps per second, self-interruptedly, and up to 35 steps per second when remote-pulse controlled. The rotary switch is an indirect drive, homing switch with 11 bank contacts for each level. The 11th contact serves as the home position for the wipers.

The wiper assembly consists of a hub and ratchet wheel, a set of wiper blades for each bank level, and an indicator wheel. A three-arm wiper arrangement per level makes it possible for all bank contacts to be traversed in only one-third revolution of the wiper assembly. The switch can also use a one-arm wiper arrangement per level.

The three arms of the wipers can be made electrically common by strapping external terminals or left separate as required by the circuitry. Because of the triple wiper arrangement, the wipers actually have 33 positions during one complete revolution of the wipers. The one-arm arrangement has only 11 positions. The wiper assemblies are so arranged that the first wiper rotates over the first bank contact level on the first 11 steps; the second wiper rotates over the second level on the next 11 steps; and the third wiper rotates over the third level on the following 11 steps. Three off-normal spring cam lobes operate the off-normal springs when the wipers are at normal. When desired, the lobes can be removed from the 11th and 22d position, so that the off-normal springs are operated in the home position or once during each revolution of the wipers.

The rotary switch becomes versatile for many circuit applications through the use of: one-arm and three-arm wiper arrangements, straps on the wipers, and varying the number of banks. The noise and balance, and loop around test circuits use the common wiper with the 3-arm arrangement for 11-step operation. The reverse battery test circuit uses the 1-arm wiper arrangement, and the switch will take 33 steps before reaching the home position. The rotary switches operate from 60 and 120 IPM ground to control the completely automatic operation sequence of the test circuits.

Exercises (815):

1. What is the purpose of the noise and balance test line circuit?

2. What is the reverse battery test line circuit used for?

3. What is the purpose of the end office loop around test circuit?

4. What is the connector access number for the noise and balance test line circuit?

5. What are the terminations provided by the end office loop around test circuit?

816. Using figure 3-2 and foldout 8, specify the actions that occur in the noise and balance test line circuit during operation.

Noise and Balance Test Line Circuit. The noise and balance test line circuit—seen in foldout 8, figure 3,c— is terminated in the PABX station to allow the AUTOVON switch to make noise and balance (return loss and singing) test. The circuit is marked idle to preceding equipment by resistance battery, as figure 3-2 shows (via the winding of relay TR), on lead C. Use AC and Y wiring options.

Circuit Accessed From Connector Terminal 41

NOISE AND BALANCE TEST LINE CIRCUIT H-83195

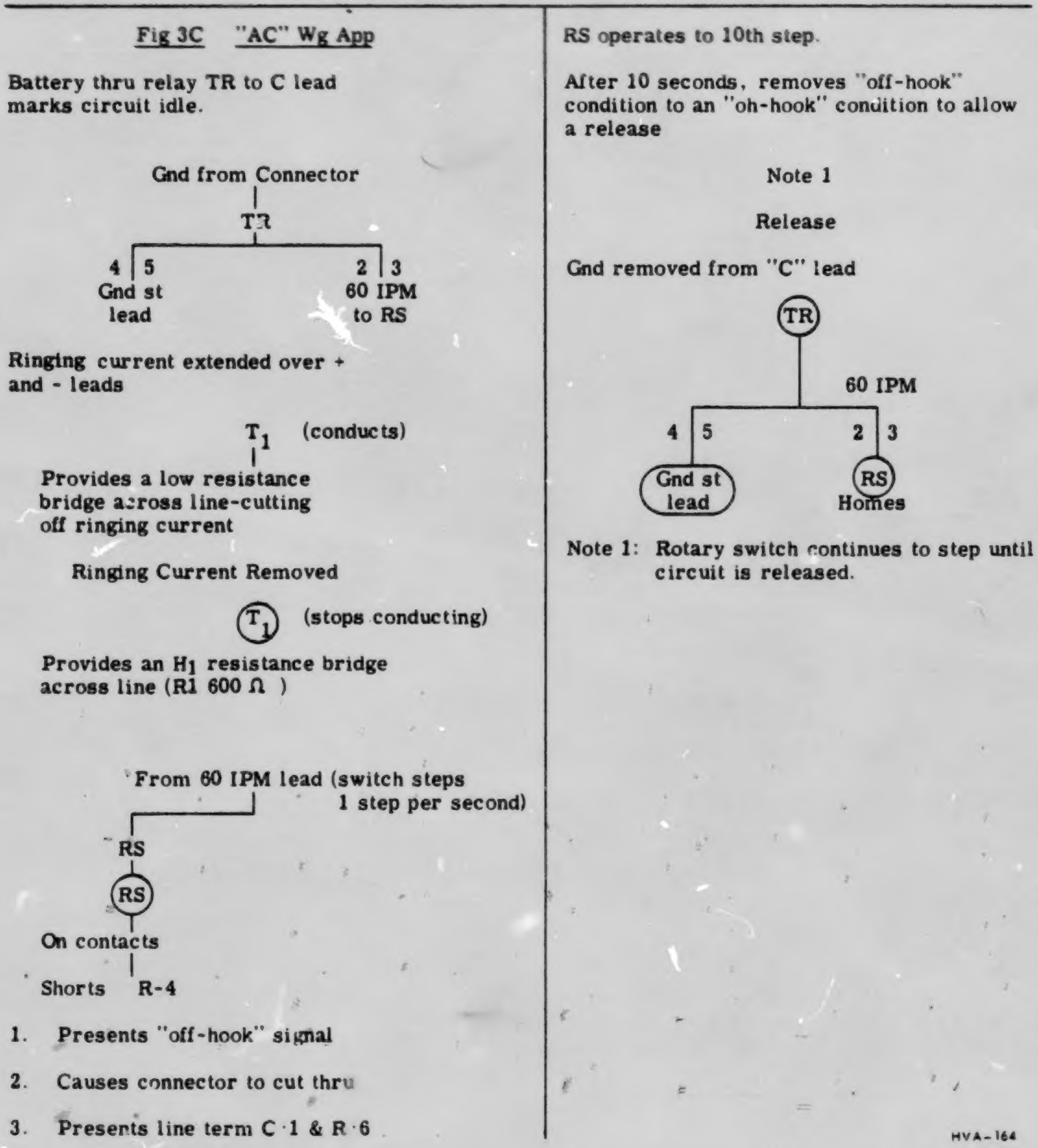

Fig 3C "AC" Wg App

Battery thru relay TR to C lead marks circuit idle.

Gnd from Connector

TR

4 | 5 Gnd st lead

2 | 3 60 IPM to RS

Ringing current extended over + and - leads

T_1 (conducts)

Provides a low resistance bridge across line-cutting off ringing current

Ringing Current Removed

T_1 (stops conducting)

Provides an H_1 resistance bridge across line (R1 600 Ω)

From 60 IPM lead (switch steps 1 step per second)

RS

RS

On contacts

Shorts R-4

1. Presents "off-hook" signal
2. Causes connector to cut thru
3. Presents line term C 1 & R 6

RS operates to 10th step.

After 10 seconds, removes "off-hook" condition to an "oh-hook" condition to allow a release

Note 1

Release

Gnd removed from "C" lead

TR

60 IPM

4 | 5 Gnd st lead

2 | 3 RS Homes

Note 1: Rotary switch continues to step until circuit is released.

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Figure 3-2. Sequence of noise and balance test line circuit operation.

Seizure. Seizure occurs when the AUTOVON switch technician dials the assigned test number. The connector grounds lead C operating relay TR and marking the circuit busy. The connector extends ringing current over lead "+" and "−" causing tube T1 to conduct. When the connector switches through, 900-ohm, 2-microfarad line termination is returned to AUTOVON switch:

a. TR relay operates. TR contacts 2 and 3 complete a circuit to rotary switch RS via the 60 IPM punching. TR contacts 4 and 5 ground lead ST to start interrupters if required. TR contacts 6 and 7 serves no function at this time.

b. T1 conducts. T1 fires and presents a low resistance bridge across the line to cut off ringing current. This simulates called party answering to the connector. When ringing current is removed, T1 stops conducting.

c. T1 stops conducting. When T1 stops conducting, the loop via the RET coil and resistor R4 presents an on-hook condition to the connector.

d. RS steps. Rotary switch RS steps in response to 60 IPM. Since the rotary switch is an indirect drive switch, it will step when RS releases. During the first step, the ON (off-normal) contacts restore.

> NOTE: The ON contacts release during the first step, because they are normally operated in the home position by the cam lobes.

e. "ON" contacts release. ON contacts 3 and 4 short circuit resistor R4 for 10 seconds to give off-hook supervision for connector cut-through and to return line termination to AUTOVON via capacitor C1 and R6.

f. RS homes. After 10 seconds rotary switch, RS steps to the 11 position and operates the ON contacts.

g. "ON" contacts operate. ON contacts 3 and 4 open the short circuit on resistor R4 to give on-hook supervision to the connector and AUTOVON for 1 second. The rotary switch will continue to step to 60 IPM until the connector is released, giving 10 seconds off-hook and 1 second on-hook supervision.

Release. At the completion of the noise and balance test, AUTOVON will release the circuit releasing the connector. When the connector is released, ground is removed from the C lead, releasing relay TR:

a. TR relay releases. TR contacts 4 and 5 remove the ground on lead ST. TR contacts 1 and 2 complete a homing circuit to rotary switch RS.

b. RS homes. The rotary switch steps self-interruptedly to its home position operating its ON contacts 1 and 2 breaking the home circuit.

Exercises (816):

Use foldout 8 to complete the following.

1. What circuit actions are ON contacts 1 and 2 responsible for?

2. If Z wiring were used in place of Y wiring, what would the termination be to the connector?

3. What tube terminals (T1) provide the low resistance bridge across the line to cut off ringing?

4. What causes tube T1 to conduct?

817. Using figures 3-3A, 3-3B, and 3-3C and foldout 9 as necessary, distinguish among the actions that occur in the reverse battery test line circuit during operation.

Reverse Battery Test Line Circuit. The reverse battery test line circuit—shown in foldout 9, figure 2—is terminated in the PABX to allow AUTOVON switch to test the supervisory functions of the AUTOVON interface trunk circuits. The circuit is marked idle to preceding equipment by resistance battery, shown in figures 3-3A, 3-3B, and 3-3C (via the winding of relay D), on lead CN. After seizure and cut-through the circuit provides the following sequence of supervisory signals to the equipment under test:

- Off-hook for 1¼ seconds.
- On-hook for 1/2 second.
- Off-hook for 1½ seconds.
- 120 IPM (3 flashes).
- On-hook for 2 seconds.
- Off-hook for 5½ seconds.

The 2 seconds on-hook, 5½ seconds off-hook signals are repeated until the circuit is released.

The reverse battery test line circuit rotary switch employs the one-arm wiper arrangement. Wipers A and B rotate over the bank contacts on steps 1 through 11, wipers C and D rotate over the banks on steps 12 through 22, and wiper E rotates over the bank on steps 23 through 33.

Seizure. Seizure occurs when the AUTOVON switch technician dials the assigned test number. We will discuss the detailed operation of the test circuits by analyzing the 33 steps of the rotary switch RS:

Circuit Accessed From Connector Terminal 31

REVERSE BATTERY TEST LINE CIRCUIT H-610036

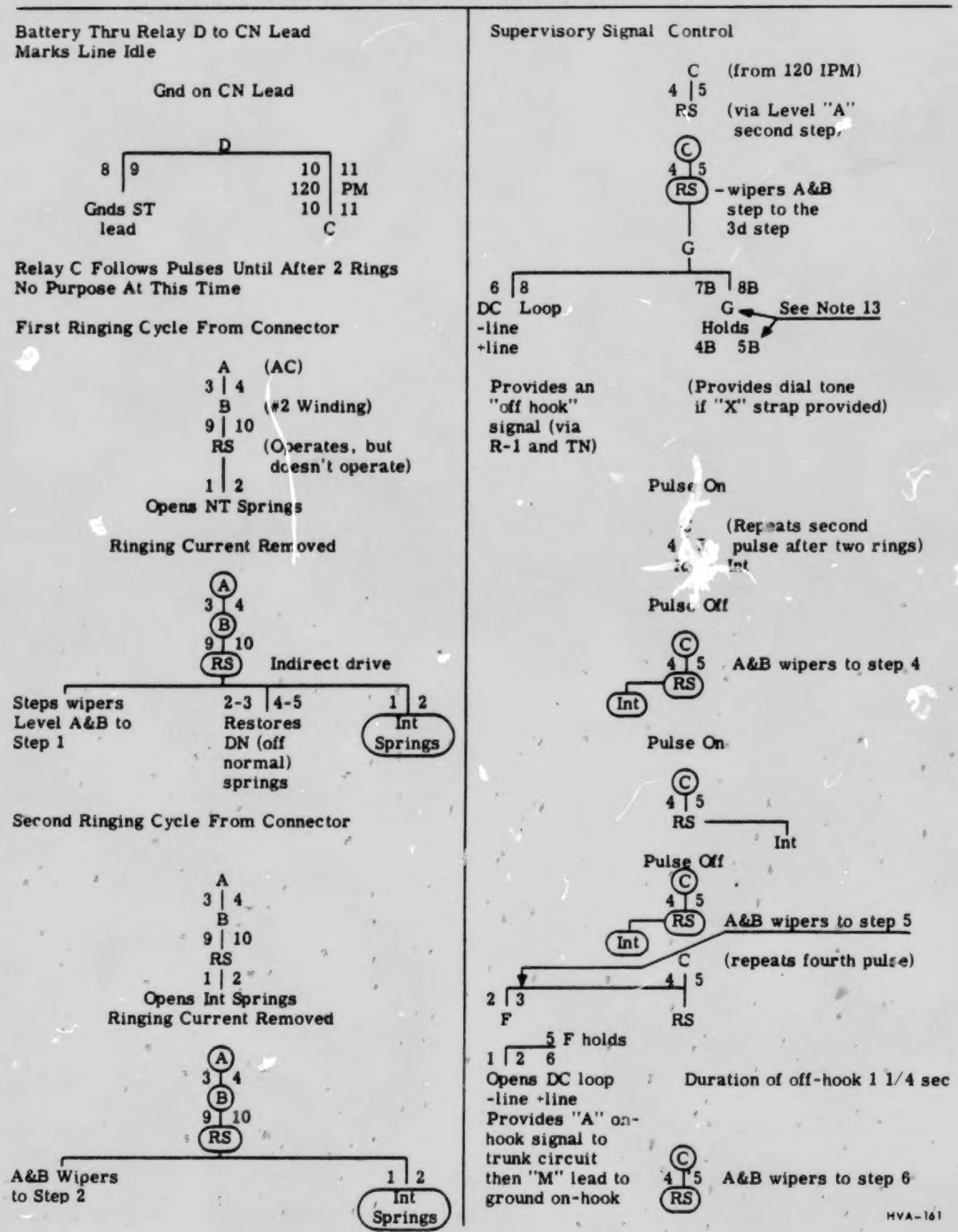

Figure 3-3A. Sequence of reverse battery test line circuit operation.

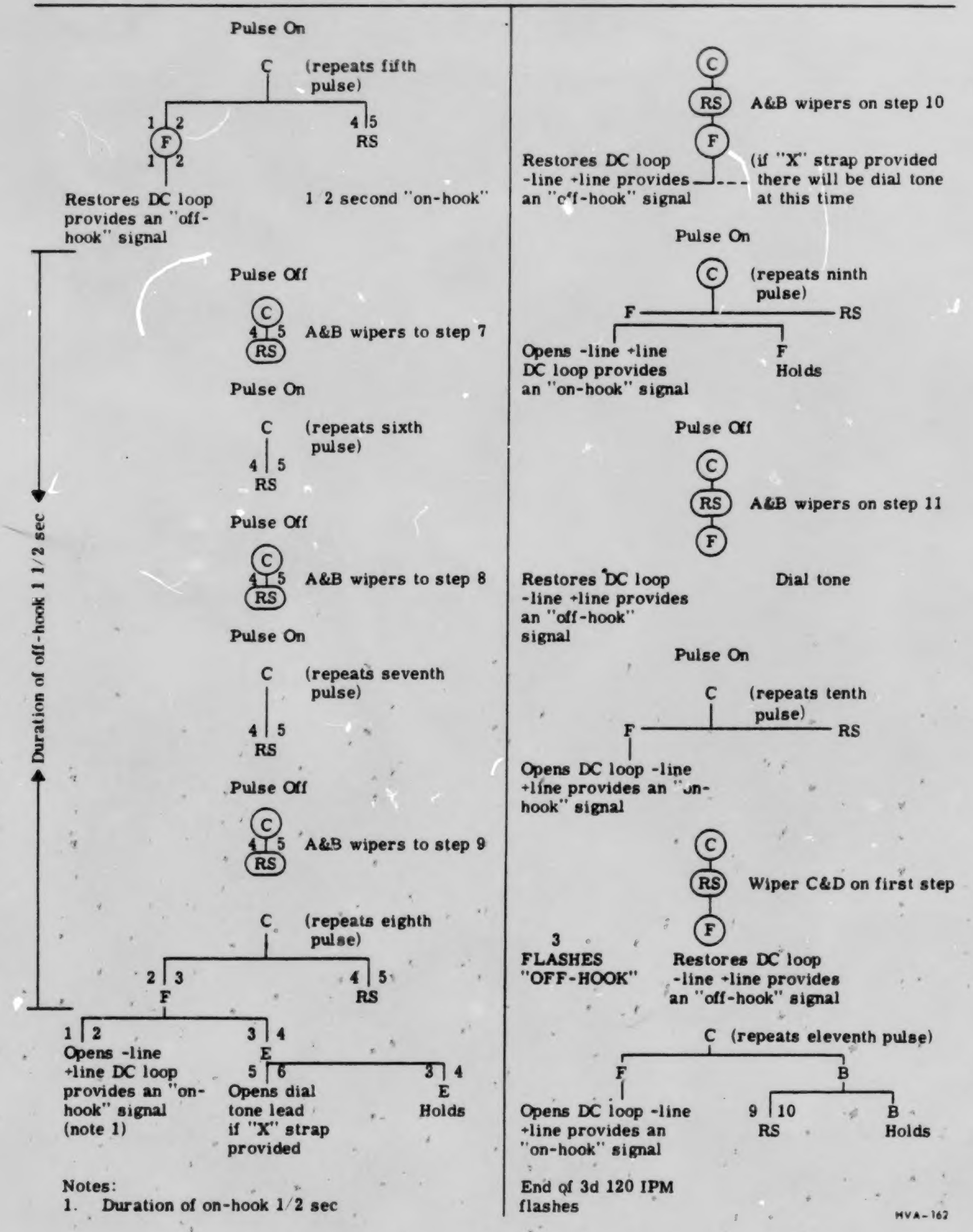
Pulse On
C (repeats fifth pulse)
1 2
F
1 2
4 5
RS
Restores DC loop provides an "off-hook" signal
1 2 second "on-hook"
Pulse Off
C
4 5
RS
A&B wipers to step 7
Pulse On
C (repeats sixth pulse)
4 5
RS
Pulse Off
C
4 5
RS
A&B wipers to step 8
Pulse On
C (repeats seventh pulse)
4 5
RS
Pulse Off
C
4 5
RS
A&B wipers to step 9
C (repeats eighth pulse)
2 3
F
4 5
RS
1 2
Opens -line +line DC loop provides an "on-hook" signal (note 1)
3 4
E
5 6
Opens dial tone lead if "X" strap provided
3 4
E
Holds
Duration of off-hook 1 1/2 sec
Notes:
1. Duration of on-hook 1/2 sec
C
RS
A&B wipers on step 10
F
Restores DC loop -line +line provides an "off-hook" signal
(if "X" strap provided there will be dial tone at this time
Pulse On
C (repeats ninth pulse)
F
RS
Opens -line +line DC loop provides an "on-hook" signal
F
Holds
Pulse Off
C
RS
A&B wipers on step 11
F
Restores DC loop -line +line provides an "off-hook" signal
Dial tone
Pulse On
C (repeats tenth pulse)
F
RS
Opens DC loop -line +line provides an "on-hook" signal
C
RS
Wiper C&D on first step
F
3 FLASHES "OFF-HOOK"
Restores DC loop -line +line provides an "off-hook" signal
C (repeats eleventh pulse)
F
B
Opens DC loop -line +line provides an "on-hook" signal
9 10
RS
B
Holds
End of 3d 120 IPM flashes
HVA-162

Figure 3-3B. Sequence of reverse battery test line circuit operation.

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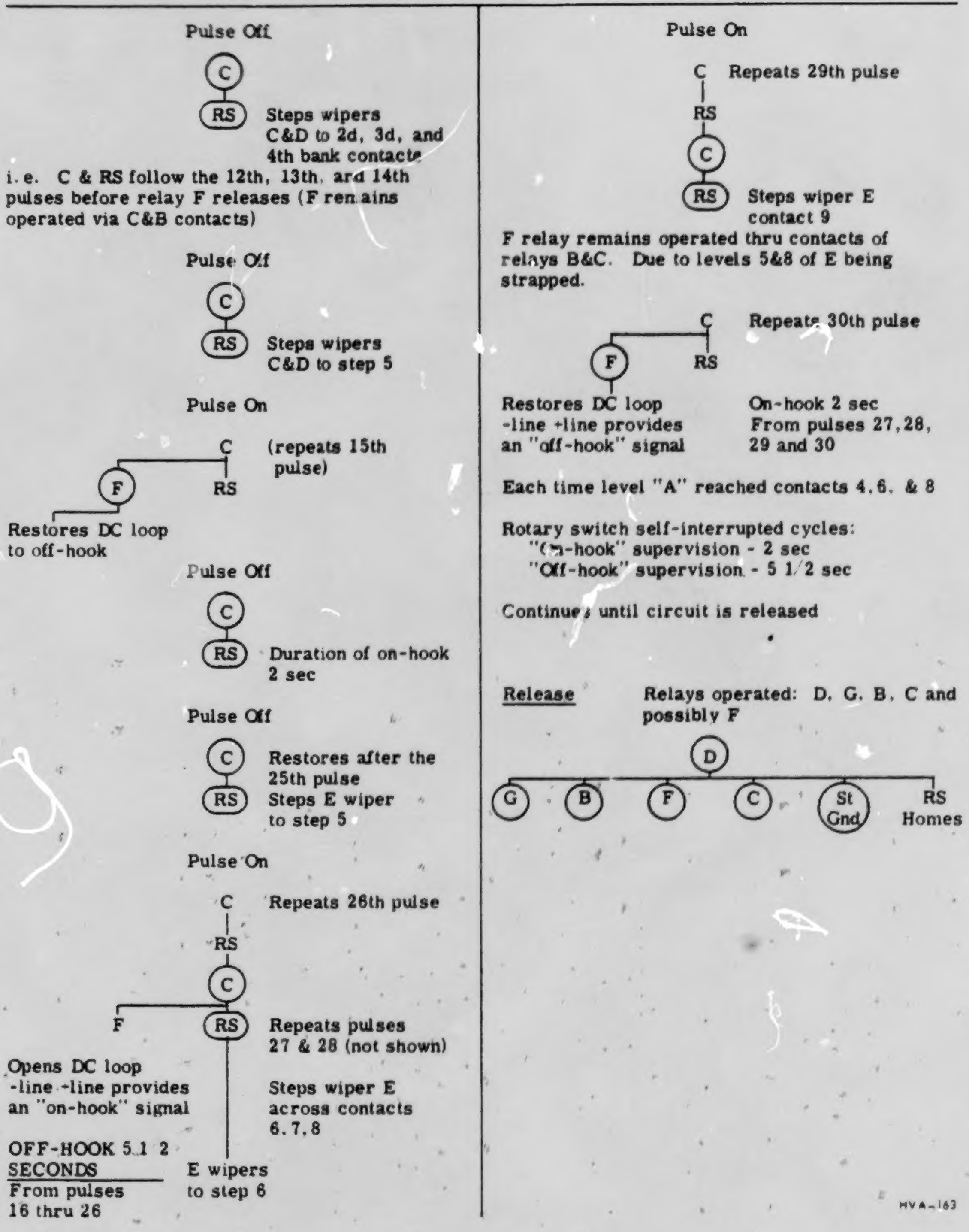
REVERSE BATTERY TEST LINE CIRCUIT H-610036


Pulse Off
C
RS
Steps wipers C&D to 2d, 3d, and 4th bank contacts

i.e. C & RS follow the 12th, 13th, and 14th pulses before relay F releases (F remains operated via C&B contacts)

Pulse Off
C
RS
Steps wipers C&D to step 5
Pulse On
C
(repeats 15th pulse)
F
RS
Restores DC loop to off-hook
Pulse Off
C
RS
Duration of on-hook 2 sec
Pulse Off
C
RS
Restores after the 25th pulse
Steps E wiper to step 5
Pulse On
C
Repeats 26th pulse
RS
C
F
RS
Repeats pulses 27 & 28 (not shown)
Opens DC loop -line -line provides an "on-hook" signal
Steps wiper E across contacts 6, 7, 8
OFF-HOOK 5 1/2 SECONDS
From pulses 16 thru 26
E wipers to step 6
Pulse On
C
Repeats 29th pulse
RS
C
RS
Steps wiper E contact 9

F relay remains operated thru contacts of relays B&C. Due to levels 5&8 of E being strapped.

C
Repeats 30th pulse
F
RS
Restores DC loop -line +line provides an "off-hook" signal
On-hook 2 sec
From pulses 27, 28, 29 and 30

Each time level "A" reached contacts 4, 6, & 8

Rotary switch self-interrupted cycles:
"On-hook" supervision - 2 sec
"Off-hook" supervision - 5 1/2 sec

Continues until circuit is released

Release
Relays operated: D, G, B, C and possibly F
D
G
B
F
C
St Gnd
RS Homes
HVA-163

Figure 3-3C. Sequence of reverse battery test line circuit operation.

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a. The connector closes the line loop to the test circuit and grounds leads CN. Ground on lead CN operates relay D and marks the test circuit busy:

(1) D relay operates. D contacts 4 and 5 complete a hold path for itself on lead CN. D contacts 8 and 9 ground the ST lead to start the interrupters. D contacts 10 and 11 complete a circuit to operate relay C to 120 IPM ground. The operation of relay C will determine the time sequence of the automatic operation of the test circuit. Relay C serves no function until after two ringing cycles.

(2) A relay operates. A contacts 3 and 4 complete a circuit to relay B.

(3) B relay operates. B contacts 9 and 10 complete a circuit to rotary switch RS.

(4) RS operates. Rotary switch RS will not step its wipers at this time, since it is an indirect drive switch. RS interrupter contacts 1 and 2 open but serve no purpose at this time.

> NOTE: Since ringing current from the connector is interrupted, relay A will remain operated only 1 second and release for 4 seconds before operating again.

b. After 4 seconds of silence, ringing current will again be extended over the line loop operating relay A:

(1) A relay operates. A contacts 3 and 4 complete a circuit to relay B.

(2) B relay operates. B contacts 9 and 10 complete a circuit to rotary switch RS.

(3) RS operates. Rotary switch RS opens its interrupter contacts 1 and 2.

> NOTE: After 1 second of ringing, ringing current is removed from the line loop releasing relay A.

(4) A relay releases. A contacts 3 and 4 open the circuit to relay B.

(5) B relay releases. B contacts 9 and 10 open the circuit to rotary switch RS.

(6) RS releases. Rotary switch RS closes its interrupter contacts and steps wiper contacts A and B to bank contact No. 2 (step 2):

c. Relay C has been operating to the 120 IPM punching but has served no purpose until now. Since the rotary switch is setting on bank contact No. 2, when relay C operates to 120 IPM ground a second operate path for the rotary switch will be completed. Relay C operates and releases every 1/2 second to 120 IPM ground:

(1) C relay operates. C contacts 4 and 5 complete a circuit to rotary switch RS (via wiper A and bank contact 2).

(2) RS operates. RS opens its interrupter contacts 1 and 2.

(3) C relay releases. C contacts 4 and 5 open the circuit to rotary switch RS.

(4) RS releases. RS will step wipers A and B to contact No. 3 (step 3) and closes its interrupter contacts.

d. When the wiper steps on the third bank, a circuit is completed to relay G:

(1) G relay operates. G contacts 6T and 8T complete a 1,000-ohm DC off-hook termination to the connector and AUTOVON switch. This causes the connector to cut-through and trip ringing current. G contacts 7T and 8T open the circuit to relay A. G contacts 7B and 8B complete a hold path for itself. G contacts 4T and 5T complete a circuit for dial tone if *X* wiring is used. Dial tone will be returned to the preceding equipment with each off-hook signal.

(2) C relay operates. C contacts 4 and 5 complete a circuit to rotary switch RS (via relay G contacts 2T and 3T).

(3) RS operates. RS opens its interrupter contacts 1 and 2.

(4) C relay releases. C contacts 4 and 5 open the circuit to RS.

(5) RS releases. RS steps wipers A and B to contact No. 4 (step 4) and closes its interrupter contacts.

e. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to rotary switch RS.

(2) RS operates. RS opens its interrupter contacts 1 and 2.

(3) C relay releases. C contacts 4 and 5 open the circuit to RS.

(4) RS releases. RS steps wipers A and B to contact No. 5 (step 5) and closes its interrupter contacts. When the B wiper steps on the fifth contact, it prepares a circuit to relay F.

f. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to RS. C contacts 2 and 3 complete a circuit to relay F.

(2) RS operates. RS opens its interrupter contacts 1 and 2.

(3) F relay operates. F contacts 1 and 2 open the 1,000-ohm DC line termination to give on-hook supervision to the connector and AUTOVON switch.

(4) C relay releases. Contacts 4 and 5 open the circuit to RS. C contacts 1 and 2 complete a hold path for relay F.

(5) RS releases. Rotary switch RS steps wipers A and B to contact No. 6 (step 6) and closes its interrupter contacts.

g. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to RS. C contacts 1 and 2 open the circuit to relay F.

(2) RS operates. RS opens its interrupter contacts.

(3) F relay releases. F contacts 1 and 2 close the 1,000-ohm DC line loop for off-hook supervision.

(4) C relay releases. C contacts 4 and 5 open the circuit to RS.

(5) RS releases. Rotary switch RS steps wipers A and B to contact No. 7 (step 7) and closes its interrupter contacts.

h. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to RS.

(2) RS operates. RS opens its interrupter contacts.

(3) C relay releases. C contacts 4 and 5 open the circuit to RS.

(4) RS releases. Rotary switch RS steps wipers A and B to contact No. 8 (step 8) and closes its interrupter contacts.

i. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to RS.

(2) RS operates. RS opens its interrupter contacts.

(3) C relay releases. C contacts 4 and 5 open the circuit to RS.

(4) RS releases. Rotary switch RS steps wipers A and B to contact No. 9 (step 9) and closes its interrupter contacts.

j. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to RS. C contacts 2 and 3 complete a circuit to relay F (via wiper B, contact 9).

(2) RS operates. RS opens its interrupter contacts.

(3) F relay operates. F contacts 1 and 2 open the 1,000-ohm DC loop to return on-hook supervision. F contacts 3 and 4 complete a circuit to relay E (via wiper A, contact 9).

(4) E relay operates. E contacts 5 and 6 close a circuit for dial tone to induction coil TN, if *X* strap was not provided. Dial tone would now be returned, during each off-hook signal, to the preceding equipment. E contacts 3 and 4 provide a hold path for itself. E contacts 1 and 2 prevent relay F from holding when relay C releases.

(5) C relay releases. C contacts 4 and 5 open the circuit to RS. C contacts 2 and 3 open the circuit to relay F.

(6) RS releases. Rotary switch RS steps wipers A and B to contact No. 10 (step 10) and closes its interrupter contacts.

k. Due to open contacts 2 and 3 of released C, relay F releases:

(1) F relay releases. F contacts 1 and 2 closes the 1,000-ohm DC line loop to return off-hook supervision.

(2) C relay operates. C contacts 4 and 5 complete a circuit to RS. C contacts 2 and 3 complete a circuit to relay F (via wiper B, contact 10).

(3) RS operates. RS opens its interrupter contacts.

(4) F relay operates. F contacts 1 and 2 open the 1,000-ohm DC loop to return on-hook supervision.

(5) C relay releases. C contacts 4 and 5 open the circuit to RS. C contacts 2 and 3 open the circuit to relay F.

(6) RS releases. Rotary switch RS steps wipers A and B to contact *N* (step 11), and closes its interrupter contacts.

l. Open contacts 2 and 3 of relay C:

(1) F relay releases. F contacts 1 and 2 close the 1,000-ohm DC line loop to return off-hook supervision.

(2) C relay operates. C contacts 4 and 5 complete a circuit to RS. C contacts 2 and 3 complete a circuit to relay F (via wiper B, contact *N*).

(3) RS operates. RS opens its interrupter contacts.

(4) F relay operates. F contacts 1 and 2 open the 1,000-ohm DC loop to return on-hook supervision.

(5) C relay releases. C contacts 4 and 5 open the circuit to RS. C contacts 2 and 3 open the circuit to relay F.

(6) RS releases. Rotary switch RS steps wipers C and D to contact No. 1 (step 12), and steps wipers A and B off the bank contacts. RS closes its interrupter contacts.

m. Open contacts 2 and 3 of relay C:

(1) F relay releases. F contacts 1 and 2 close the 1,000-ohm DC line loop to return off-hook supervision.

(2) C relay operates. C contacts 4 and 5 complete a circuit to RS. C contacts 2 and 3 complete a circuit to relay F (via wiper C, contact 1). C contacts 2 and 3 complete a circuit to relay B (via wiper D, contact 1).

(3) RS operates. RS opens its interrupter contacts.

(4) B relay operates. B contacts 5 and 6 provide a hold path for itself. B contacts 3 and 4 prepare a hold path for relay F.

(5) F relay operates. F contacts 1 and 2 open the 1,000-ohm DC loop to return on-hook supervision.

> NOTE: The reverse battery test line circuit will now transmit an on-hook signal for 2 seconds duration and an off-hook signal for 5½ seconds, repeated until the circuit is released.

(6) C relay releases. C contacts 4 and 5 open the circuit to RS. C contacts 2 and 3 open the operate path to relay F. Relay F will hold through C contacts 1 and 2, and the C wiper.

> NOTE: Relay F will not release during the time the rotary switch is stepping from one bank contact to the next due to the speed of the rotary switch stepping action. During the period that the C wiper is stepping over contacts 1 through 4, the F relay will hold alternately through contacts 2 and 3 of relay C and the C wiper via contacts 1 and 2.

(7) RS releases. Rotary switch RS steps wipers C and D to contact No. 2 (step 13) and closes its interrupter contacts.

n. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to RS. C contacts 2 and 3 hold relay F (via wiper C).

(2) RS operatees. RS opens its interrupter contacts.

(3) C relay releases. C contacts 4 and 5 open the circuit to RS. C contacts 1 and 2 provide a hold path for relay F.

(4) RS releases. Rotary switch RS steps wipers C and D to contact No. 3 (step 14) and closes its interrupter contacts.

o. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to RS. C contacts 2 and 3 hold relay F (via wiper C).

(2) RS operates. RS opens its interrupter contacts.

(3) C relay releases. C contacts 4 and 5 open the circuit to RS. C contacts 1 and 2 provide a hold path for relay F.

(4) RS releases. Rotary switch RS steps wipers C and D to contact No. 4 (step 15) and closes its interrupter contacts.

p. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to RS. C contacts 2 and 3 hold relay F (via wiper C).

(2) RS operates. RS opens its interrupter contacts.

(3) C relay releases. C contacts 4 and 5 open the circuit to RS. C contacts 1 and 2 provide a hold path for relay F.

(4) RS releases. Rotary switch RS steps wipers C and D to contact No. 5 (step 16) and closes its interrupter contacts.

q. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to RS. C contacts 1 and 2 open the circuit to relay F.

(2) RS operates. RS opens its interrupter contacts.

(3) F relay releases. F contacts 1 and 2 close the 1,000-ohm DC loop to return off-hook supervision.

> NOTE: This ends the 2 seconds on-hook termination and starts the 5½ seconds off-hook termination.

(4) C relay releases. C contacts 4 and 5 open the circuit to RS.

(5) RS releases. Rotary switch RS steps wipers C and D to contact No. 6 (step 17) and closes its interrupter contacts.

r. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to RS.

(2) RS operates. RS opens its interrupter contacts.

(3) C relay releases. C contacts 4 and 5 open the circuit to RS.

(4) RS releases. Rotary switch RS steps wipers C and D to contact No. 7 (step 18) and closes its interrupter contacts.

> NOTE: The same series of events occur until the rotary switch releases and steps its wipers to bank contact 27.

s. 120 IPM:

(1) C relay operates. C contacts 4 and 5 complete a circuit to RS. C contacts 2 and 3 complete a circuit to relay F (via wiper E, contact 5).

(2) RS operates. RS opens its interrupter contacts.

(3) F relay operates. F contacts 1 and 2 open the 1,000-ohm DC loop to return on-hook supervision. F contacts 5 and 6 prepare a hold path for relay F during the period the E wiper is stepping across contacts 5 through 8.

The reverse battery test line circuit has now given the series of supervisory signals ended by 2 seconds of on-hook termination and 5½ seconds of off-hook termination. This nonsynchronous supervisory signal 6 (on-hook and off-hook) will be repeated until the circuit is released.

Rotary switch RS steps self-interrupted over contacts 4, 6, and 8 of level A to provide for proper timing of on-hook/off-hook supervision. For this reason, the sequence chart shows operation of the switch-through stepping of the A and B wipers. Study the sequence chart, shown in figures 3-3A, 3-3B, and 3-3C, for operation of the switch-through step 12.

Release. Relays D, G, B, D, and possibly F and C are operated prior to release. When the AUTOVON technician completes the test he will disconnect from the test circuit. When the reverse battery test line circuit reaches an on-hook termination, the connector will release, removing ground from lead CN causing relay D to release:

a. D relay releases. D contacts 10 and 11 open the pulsing circuit for relay C. D contacts 8 and 9 open the ground on lead ST. D contacts 6 and 7 open the holding ground for relays G, B, E, and F. D contacts 1 and 2 complete a homing circuit to rotary switch RS.

b. RS homes. Rotary switch RS "ON" contacts operate when the rotary switch reaches the home position breaking the homing circuit for RS.

Exercises (817):

Use foldout 9 (fig. 2) and figures 3-3A, 3-3B, and 3-3C to complete the following.

1. What is the termination provided to the connector by the reverse battery test line circuit during seizure?

2. What relay is the first to operate during seizure?

3. What happens in the reverse battery test circuit during the second ringing cycle?

4. What contacts provide the ground to operate the rotary switch the third time?

5. When does the G relay in the reverse battery test circuit operate, and to what ground does it operate?

6. When is dial tone returned to the connector with respect to the rotary switch wiper position?

818. Using foldout 10, distinguish the actions that occur in the end office loop around test circuit during a stability test.

End Office Loop Around Test Circuit. This circuit (foldout 10, fig. 4A) enables the AUTOVON technician to make one-way and two-way transmission test on each access line without the assistance of the PABX attendant. The following circuit descriptions and sequence charts (figs. 3-4A, 3-4B, and 3-4C) include circuit operation during a stability test, establishing the dB loss of an access line and completion of a loop around test. Use "SF" and "NJ" wiring options.

Stability Test. "Stability" is defined as "freedom from undesired variation." To make the stability test, the AUTOVON technician dials the required test number to access connector terminal No. 1. Connector terminal No. 1 is marked idle to the connector by resistance battery from relay LAC on the C lead.

Seizure. Upon cut-through the connector transmits ringing current over the line loop (+ and −) causing vacuum tube T1 to conduct. The circuit provides 900-ohm 2-microfarad line termination to AUTOVON upon switch-through of the connector (via R3, C3). We will discuss the detailed operation of the test circuits by analyzing the 11 steps of the rotary switch TS:

(1) T1 conducts. When the vacuum tube T1 conducts, it gives a low resistance loop to the ringing current. This causes the connector to cut off ringing current and operates relay CL1 to its "X" contacts. When ringing current is removed, the vacuum tube T1 stops conducting, and the circuit gives on-hook supervision to the connector.

(2) CL1 operation:

a. CL1 operates to "X" contacts. CL1 "X" contacts 2T and 3T complete a full operating path for CL1.

b. CL1 operates fully. CL1 contacts 3B and 4B short circuits its No. 1 winding. CL1 contacts 9B and 10B grounds lead ST to start the interrupter circuit. CL1 contacts 7B and 8B prepare a pulsing path for relay INT. CL1 contacts 5B and 6B complete a circuit to relay ST.

> NOTE: Relay ST will not operate if ground is on the 60-IPM lead at time CL1 operates due to short circuit (ground shunt) on the No. 1 winding of relay ST. Relay ST operates when 60-IPM ground pulse is removed.

(3) ST relay operates. ST contacts 4 and 5 complete a pulsing path for relay INT to the 60-IPM lead.

(4) INT relay operates. INT contacts 2 and 3 complete an operate path for rotary switch TS.

(5) TS operates. Rotary switch TS operates its interrupter contacts, but the rotary switch will not step at this time due to its indirect drive feature.

(6) INT relay releases. INT contacts 2 and 3 open the circuit to rotary switch TS.

(7) TS releases. Rotary switch TS steps its wiper to contact No. 1 (step 1) and closed its interrupter contacts. TS "ON" (off-normal) contacts close.

> NOTE: The "ON" contacts are open when the rotary switch is in the home position.

(8) "ON" contacts 3 and 4 complete an operate path for relay TT:

a. TT relay operates. TT contacts 2T and 3T, 5T and 6T close an open circuit line termination to the AUTOVON switch. TT contacts 7T and 8T short resistor R1, providing off-hook supervision to the connector.

> NOTE: The open circuit line termination is continued for 10 seconds. Relay INT continues to pulse to the 60-IPM lead stepping the rotary switch TS. When the rotary switch is on the 10th contact (step 10), the TS interrupter contacts complete a circuit to relay SH.

b. INT relay operates. INT contacts 2 and 3 complete a circuit to rotary switch TS.

c. TS operates. TS interrupter contacts 2 and 3 completes a circuit to relay SH.

d. SH relay operates. SH "X" contacts 1 and 2 complete a hold path for itself. SH contacts 7 and 8 prepare a path for short circuit line termination. SH contacts 4 and 5 prepare an operate path for relay TM. Relay TM will not operate at this time due to the stepping speed of the rotary switch. TS will have released its interrupter contacts by this time.

e. INT relay releases. INT contacts 2 and 3 opens the circuit to rotary switch TS.

f. TS releases. Rotary switch TS steps its wiper to its home position (contact N), operating its "ON" contacts. TS interrupter contacts close.

END OFFICE LOOP AROUND TEST CIRCUIT H-83243

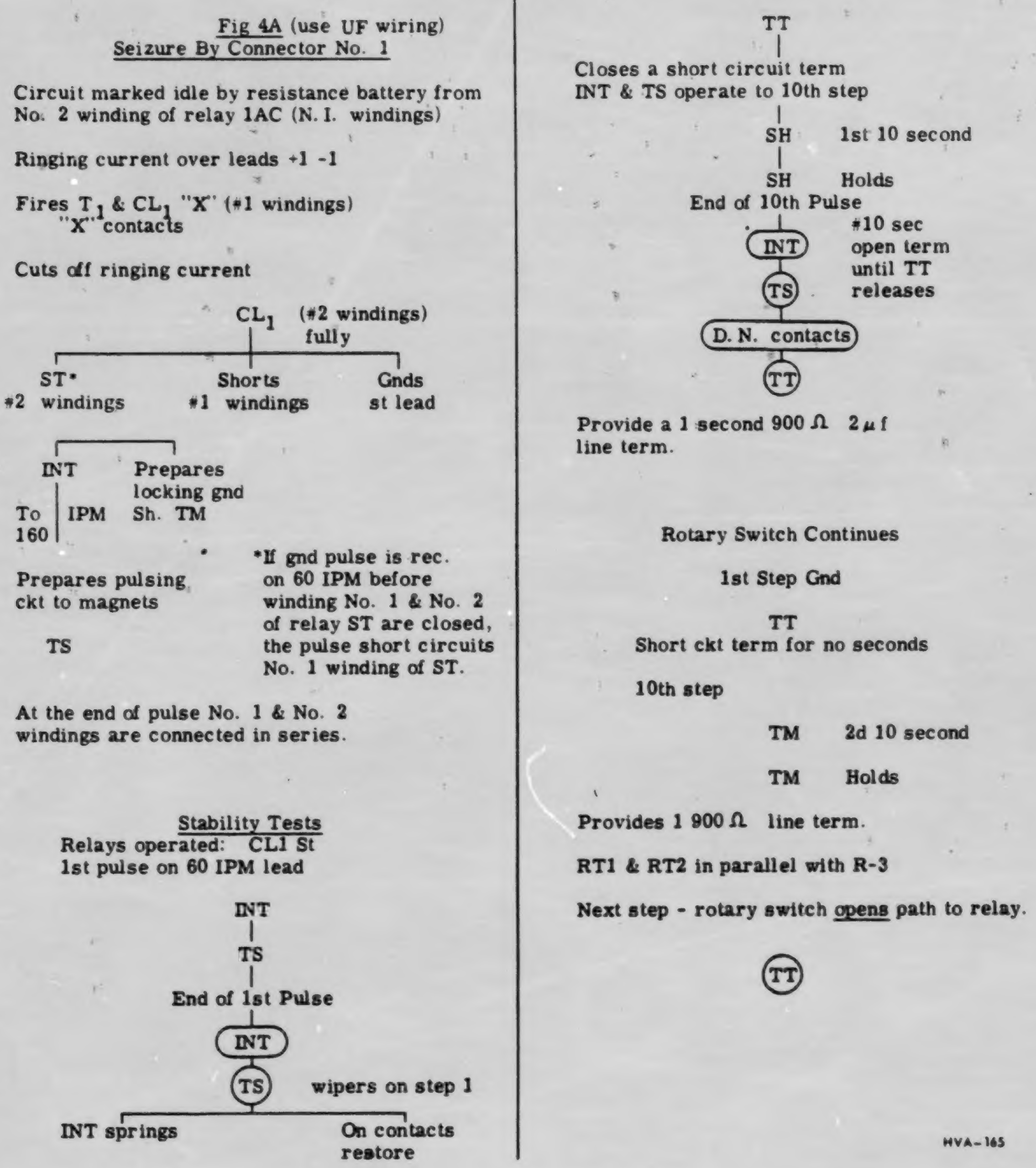

Fig 4A (use UF wiring)
Seizure By Connector No. 1

Circuit marked idle by resistance battery from No. 2 winding of relay 1AC (N. I. windings)

Ringing current over leads +1 -1

Fires T_1 & CL_1 "X" (#1 windings)
"X" contacts

Cuts off ringing current

CL_1 (#2 windings) fully

ST* #2 windings

Shorts #1 windings

Gnds st lead

INT

To 160 IPM

Prepares locking gnd Sh. TM

Prepares pulsing ckt to magnets

TS

*If gnd pulse is rec. on 60 IPM before winding No. 1 & No. 2 of relay ST are closed, the pulse short circuits No. 1 winding of ST.

At the end of pulse No. 1 & No. 2 windings are connected in series.

Stability Tests
Relays operated: CL1 St
1st pulse on 60 IPM lead

INT

TS

End of 1st Pulse

INT

TS wipers on step 1

INT springs

On contacts restore

TT

Closes a short circuit term
INT & TS operate to 10th step

SH 1st 10 second

SH Holds

End of 10th Pulse

INT

TS

#10 sec open term until TT releases

D. N. contacts

TT

Provide a 1 second 900 Ω 2 μf line term.

Rotary Switch Continues

1st Step Gnd

TT
Short ckt term for no seconds

10th step

TM 2d 10 second

TM Holds

Provides 1 900 Ω line term.

RT1 & RT2 in parallel with R-3

Next step - rotary switch opens path to relay.

TT

HVA-165

Figure 3-4A. Sequence of end office loop around test circuit operation.

END OFFICE LOOP AROUND TEST CIRCUIT H-83243

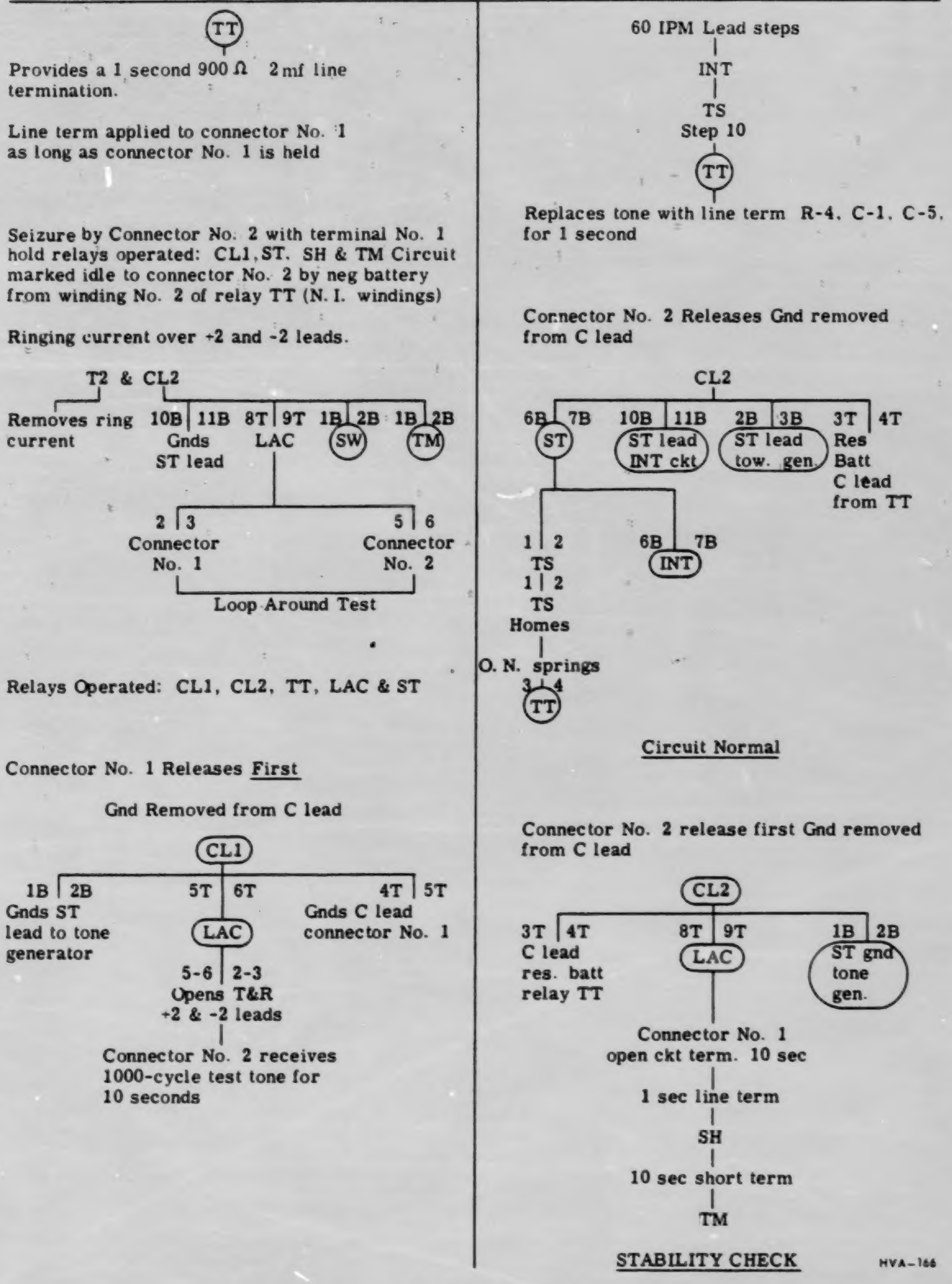
TT
Provides a 1 second 900 Ω 2 mf line termination.
Line term applied to connector No. 1 as long as connector No. 1 is held
Seizure by Connector No. 2 with terminal No. 1 hold relays operated: CL1, ST. SH & TM Circuit marked idle to connector No. 2 by neg battery from winding No. 2 of relay TT (N. I. windings)
Ringing current over +2 and -2 leads.
T2 & CL2
Removes ring current
10B | 11B Gnds ST lead
8T | 9T LAC
1B | 2B SW
1B | 2B TM
2 | 3 Connector No. 1
5 | 6 Connector No. 2
Loop Around Test
Relays Operated: CL1, CL2, TT, LAC & ST
Connector No. 1 Releases First
Gnd Removed from C lead
CL1
1B | 2B Gnds ST lead to tone generator
5T | 6T LAC
4T | 5T Gnds C lead connector No. 1
5-6 | 2-3 Opens T&R +2 & -2 leads
Connector No. 2 receives 1000-cycle test tone for 10 seconds
60 IPM Lead steps
INT
TS Step 10
TT
Replaces tone with line term R-4, C-1, C-5, for 1 second
Connector No. 2 Releases Gnd removed from C lead
CL2
6B | 7B ST
10B | 11B ST lead INT ckt
2B | 3B ST lead tow. gen.
3T | 4T Res Batt C lead from TT
1 | 2 TS
1 | 2 TS Homes
O. N. springs
3 | 4 TT
6B | 7B INT
Circuit Normal
Connector No. 2 release first Gnd removed from C lead
CL2
3T | 4T C lead res. batt relay TT
8T | 9T LAC
1B | 2B ST gnd tone gen.
Connector No. 1 open ckt term. 10 sec
1 sec line term
SH
10 sec short term
TM
STABILITY CHECK
HVA-166

Figure 3-4B. Sequence of end office loop around test circuit operation.

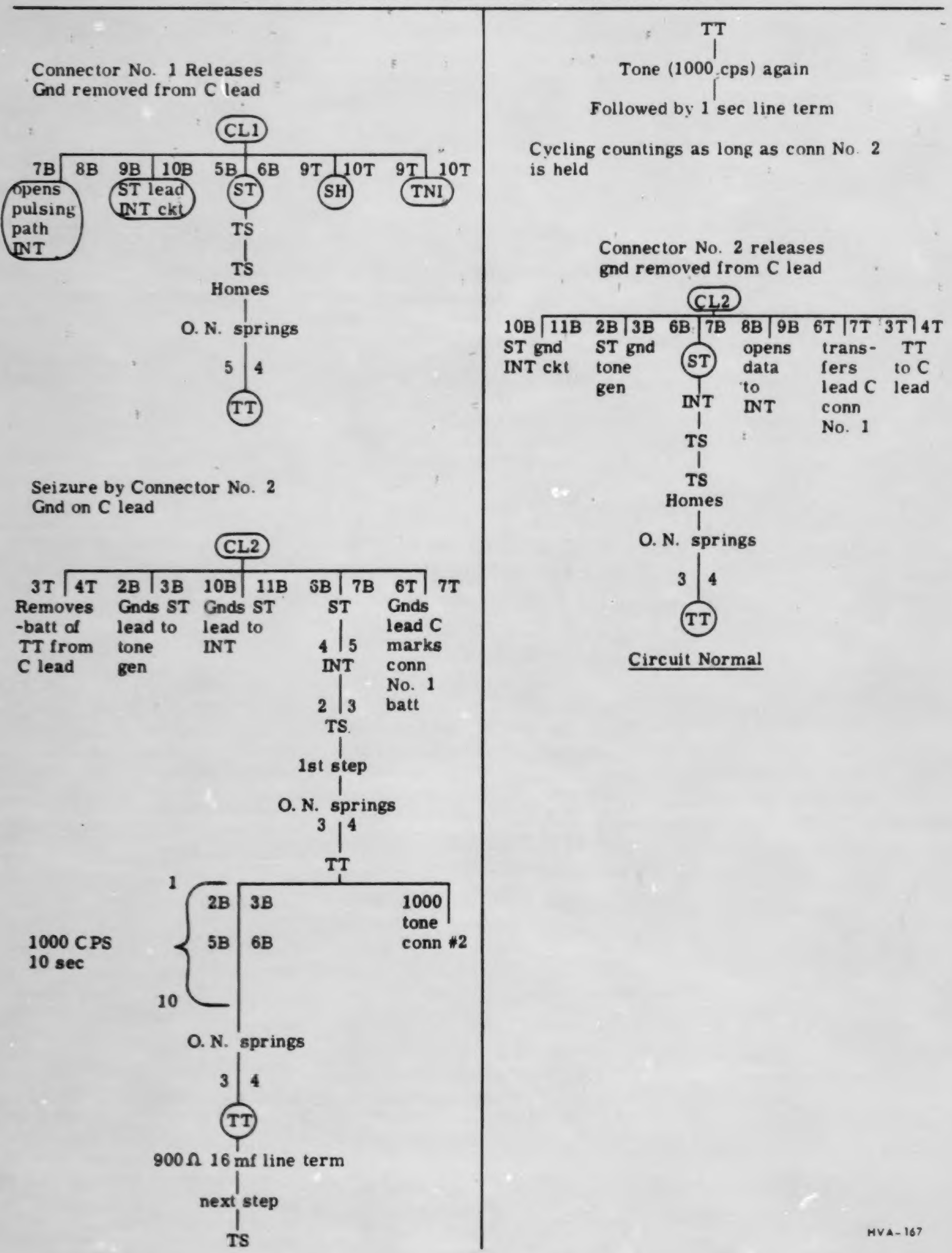

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Figure 3-4C. Sequence of end office loop around test circuit operation.

(9) "ON" contacts 3 and 4 open the circuit to relay TT:

a. TT relay releases. TT contacts 1T and 2T, 4T and 5T provide 1 second of 900-ohm 2-microfarad line termination to AUTOVON. TT contacts 7T and 8T remove the short from resistor R1 providing on-hook supervision to the connector.

b. INT relay operates. INT contacts 2 and 3 complete a circuit to rotary switch TS.

c. TS operates. Rotary switch TS operates its interrupter contacts.

d. INT relay releases. INT contacts 2 and 3 open the circuit to rotary switch TS.

e. TS releases. Rotary switch TS steps its wiper to contact No. 1 (step 1) and operates its interrupter contacts. TS releases its "ON" contacts.

> NOTE: TS has a three-arm wiper arrangement; therefore, it has only 11 steps instead of 33 as used in the reverse battery test line circuit.

(10) "ON" contacts 3 and 4 complete a circuit to relay TT:

a. TT relay operates. TT contacts 2T and 3T, 5T and 6T complete a path for short circuit line termination to AUTOVON (via C8 and "W" wiring). TT contacts 7T and 8T short resistor R1, providing off-hook supervision to the connector.

> NOTE: Relay INT will continue to pulse to 60 IPM, stepping the rotary switch TS. The short circuit line termination will last for 10 seconds. When the rotary switch is on the 10th contact (step 10), the TS interrupter contacts complete a circuit to relay TM.

b. INT relay operates. INT contacts 2 and 3 complete a circuit to rotary switch TS.

c. TS operates. TS interrupter contacts 2 and 3 complete a circuit to relay TM.

d. TM relay operates. TM "X" contacts 1 and 2 complete a hold path for itself. TM contacts 7 and 8 prepare a circuit for 900-ohm 2-microfarad line termination.

e. INT relay releases. INT contacts 2 and 3 open the circuit to rotary switch TS.

f. TS releases. Rotary switch TS steps its wiper to the home position (contact N), operating its "ON" contacts. TS interrupter contacts release.

(11) "ON" contacts 3 and 4 open the circuit to relay TT:

a. TT relay releases. TT contacts 7T and 8T remove the short on resistor R1, providing on-hook supervision to the connector. TT contacts 1T and 2T, 4T and 5T complete a path for 900-ohm 2-microfarad line termination to AUTOVON.

b. The rotary switch will continue to step until the circuit is released. Relay TT will operate for 10 seconds and release for 1 second. AUTOVON will receive the 900-ohm 2-microfarad line termination continuously until the circuit is released.

Release. Since release sequence is the same for each time the circuit is released, we will discuss circuit operation during release from a loop around test. Assume that all relays are released, and the rotary switch is in the home position.

Exercises (818):

1. What is the purpose of the end office loop around test circuit?

Use foldout 10, figure 4A, to complete the following.

2. What line termination does AUTOVON see when the connector switches through to terminal 1? Terminal 2?

3. When does the TT relay release and what circuit action is responsible for its release during a stability test?

819. Using foldout 10, identify the actions that occur in the end office loop around test circuit when establishing known dB loss.

Establishing Known dB Loss. To establish a known dB loss, connector terminal No. 2 must be accessed. This will connect the 1,000-Hz tone supply (TTS-39B) to the end office loop around test circuit. The AUTOVON technician can then measure the 1,000-Hz, 0-dB tone to determine the dB loss of the access line.

Seizure. Access to connector terminal No. 2 is obtained by dialing the assigned test number. The test circuit is marked idle by resistance battery (via winding relay TT) on the C lead:

a. Upon seizure, ringing current is extended over the line loop (− and +), causing vacuum tube T2 to conduct:

(1) T2 conducts. T2 conducting offers a low resistance line loop, causing the connector to cut off ringing current and operate CL2 to its "X" contacts.

(2) CL2 operates to "X" contacts. CL2 "X" contacts 1T and 2T complete a full operating path for itself.

(3) CL2 relay operates. CL2 contacts 2B and 3B ground ST lead to start 1,000-Hz tone supply (TTS-39B). CL2 contacts 4B and 5B short out the No. 1 winding of CL2. CL2 contacts 6T and 7T ground the C lead on connector terminal No. 1, marking it busy. CL2 contacts 10B and 11B ground lead ST to start interrupter circuit. CL2 contacts 6B and 7B complete a circuit to relay ST.

NOTE: CL2 contacts 8B and 9B close a circuit to shunt No. 1 winding of relay ST to prevent it from operating if 60-IPM lead is grounded.

(4) ST relay operates. ST contacts 4 and 5 complete a circuit to pulse relay INT to the 60-IPM lead.

(5) INT relay operates. INT contacts 2 and 3 complete a circuit to rotary switch TS.

(6) TS operates. Rotary switch TS operates its interrupter contacts but does not step its wiper due to the indirect drive feature.

(7) INT relay releases. INT contacts 2 and 3 open the circuit to rotary switch TS.

(8) TS releases. Rotary switch TS steps its wiper to contact No. 1 and releases its interrupter contacts. TS "ON" contacts release.

b. "ON" contacts 3 and 4 complete a circuit to relay TT:

(1) TT relay operates. TT contacts 7B and 8B provide off-hook supervision to the connector. TT contacts 5B and 6B, 2B and 3B complete a circuit to provide the 1,000-Hz, 0-dB test tone to the AUTOVON technician.

(2) The rotary switch will continue to step in response to relay INT, which is pulsing to the 60-IPM lead. The 1,000-Hz, 0-dB test tone will be returned to AUTOVON for 10 seconds and removed for 1 second via the contacts of relay TT. When the rotary switch is in the home position the "ON" contacts operate breaking the circuit to relay TT. This removes the 1,000-Hz, 0-dB test tone and replaces it with 900-ohm 16-microfarad line termination.

Release. Release will be similar to release from the loop around test which is discussed next. Assume that all relays are released and that the rotary switch is in the home position.

Exercises (819):

1. Which connector terminal, of the end office loop around test circuit, is used when performing the established known dB loss test?

2. At what level is the 1,000-Hz test tone transmitted?

3. What effect do resistors R5 through R9 have on the 1,000-Hz test tone when the dB loss is being established? Why?

820. Using foldout 10, identify the actions that occur in the end office loop around test circuit during the loop around test.

Loop Around Test. The AUTOVON technician must access connector terminal No. 1, first, and then, connector terminal No. 2 to make the loop around test. In the previous circuit description the AUTOVON technician made a stability test on the first access line (line A, fig. 3-1). He then determined the dB loss of the access line. He will now access connector terminal No. 1 with the next access line (line B, fig. 3-1) to be tested. Access of connector terminal No. 1 will be the same for this line as previously described during a stability test. The AUTOVON technician will make a stability test of the second access line. After completion of the stability test, he will hold the access line and access connector terminal No. 2 with the initial access line (line A, fig. 3-1).

Seizure. Relays CL1, ST, SH, TM, and possibly TT are operated because of connector terminal No. 1 being held operated.

Upon seizure of connector terminal No. 2, ringing current is extended over the line loop (− and +), causing vacuum tube T2 to conduct:

a. T2 conducts. T2 conducting offers a low resistance line loop causing the connector to cut off ringing current and operates relay CL2 to its "X" contacts.

b. CL2 operates to "X" contacts. CL2 "X" contacts 1T and 2T complete a full operate path for itself.

c. CL2 relay operates. CL2 contacts 4B and 5B short out its No. 1 winding. CL2 contacts 3T and 4T remove the resistance battery from the C lead. CL2 contacts 6B and 7B complete a circuit for an alternate ground to relay ST. CL2 contacts 8B and 9B complete an alternate path for 60-IPM ground. CL2 contacts 1B and 2B open the circuit to relay SH and TM. CL2 contacts 8T and 9T complete a circuit to relay LAC. CL2 contacts 10T and 11T complete a circuit to short resistor R2 to return off-hook supervision to the connector.

NOTE: Since connector terminal No. 1 is being held, rotary switch TS is continuously stepping. Relay TT will be operated 10 seconds and released 1 second in response to the "ON" contacts 3 and 4.

d. SH relay releases. Relay SH serves no function at this time.

e. TM relay releases. Relay TM serves no function at this time.

f. LAC relay operates. LAC contacts 2 and 3 and 5 and 6 connect connector terminal No. 1 to connector terminal No. 2 for the loop around test.

The AUTOVON technician will have the circuitry for making the loop around test for 10 seconds interrupted for 1 second by 900-ohm 2-microfarad line termination to connector terminal No. 2. This condition will be repeated until the circuits are released. Relays operated are CL1, CL2, LAC, TT, and ST. Relay INT is pulsing to 60 IPM, and relay TT is operated for 10 seconds and released for 1 second.

Release. The AUTOVON technician can release either connector terminal No. 1 or 2 first. Therefore, we will first cover release of connector terminal No. 1 and then the release of connector terminal No. 2. Relays operated prior to relase are CL1, CL2, ST, LAC, and possibly TT:

a. When the technician releases connector terminal No. 1, ground is removed from the C lead releasing relay CL1:

(1) CL1 relay releases. CL1 contacts 4T and 5T complete a circuit for ground on the C lead to mark connector terminal No. 1 busy. CL1 contacts 5T and 6T open the circuit to relay LAC. CL1 contacts 1B and 2B ground lead ST to start 1,000-Hz test tone supply (TTS-39B).

(2) LAC relay releases. LAC contacts 10 and 11 and 7 and 8 complete a circuit for 1,000-Hz, 0-dB test tone to connector terminal No. 2.

> NOTE: The 1,000-Hz test tone (10 seconds), followed by 900-ohm 16-microfarad line termination (1 second), is repeated until connector terminal No. 2 is released. Release of connector terminal No. 2 removes ground from lead C releasing relay CL2.

(3) CL2 relay releases. CL2 contacts 6T and 7T remove the ground marking connector terminal No. 1 busy. CL 2 contacts 3T and 4T place resistance battery on lead C to mark connector terminal No. 2 idle. CL2 contacts 5T and 6T place resistance battery on lead C to mark connector terminal No. 1 idle. CL2 contacts 6B and 7B open the circuit to relay ST. CL2 contacts 8B and 9B open the pulsing path for relay INT. CL2 contacts 10B and 11B remove ground on the ST lead to interrupter circuit. CL2 contacts 2B and 3B remove ground on the ST lead to 1,000-Hz test tone supply.

(4) ST relay releases. ST contacts 1 and 2 complete an operate path for rotary switch TS.

(5) TS operates. Rotary switch TS steps self-interruptedly to its home position. TS "ON" contacts 1 and 2 open the homing circuit.

> NOTE: The circuit is now at normal. The AUTOVON technician could have released connector terminal No. 2 first. Release of the connector caused ground to be removed from the C lead releasing relay CL2.

(6) CL2 relay releases. CL2 contacts 8T and 9T open the circuit to relay LAC. CL2 contacts 1B and 2B prepare a lockup path for relays SH and TM.

(7) LAC relay releases. LAC contacts 1 and 2 and 4 and 5 return open line termination to connector terminal No. 1.

> NOTE: The rotary switch TS will step under control of relay INT. The circuit operation will be the same as in a stability test in which the following line terminations are returned to connector terminal No. 1:

- 10 seconds open - 1 second 900-ohm 2-microfarad.
- 10 seconds short circuit (C8) - 1 second 900-ohm 2-microfarad.
- Continuous 900-ohm 2-microfarad until circuit is released.

b. The AUTOVON technician will now release connector terminal No. 2. When the connector is released, ground is removed from the C lead releasing relay CL1:

(1) CL1 relay releases. CL1 contacts 5B and 6B open the circuit to relay ST. CL1 contacts 7B and 8B open the pulsing path for relay INT. CL1 contacts 9B and 10B remove ground from the ST lead to interrupter circuit. CL1 contacts 9T and 10T open the circuit to relays SH and TM.

(2) SH relay releases. SH relay serves no function at this time.

(3) TM relay releases. TM relay serves no function at this time.

(4) ST relay releases. ST contacts 1 and 2 complete a circuit to rotary switch TS.

(5) TS operates. Rotary switch TS steps self-interruptedly to its home position operating its "ON" contacts 1 and 2 opening the homing circuits.

Exercises (820):

1. During the loop around test, what contacts tie the tip and ring of terminal 1 to tip and ring of terminal 2? What terminal must be accessed first?

2. What contacts provide the ground that allows the rotary switch TS to step self-interruptedly to the home position?

3-2. Test Equipment

The interface equipment, like the Strowger and XY equipment, requires some special test equipment as well as some test equipment that is used in all central offices.

In this section you will spend your time with the special test equipment primarily. Multimeters and current flow test sets, though used, do not require discussion at this time.

821. Give the specific purpose of each of a group of selected pieces of test equipment used to test and maintain interface equipment.

The make and model of any given piece of test equipment used to test and maintain the AUTOVON interface equipment may vary from one central office to another. However, you are interested in what a particular piece of equipment does and not the differences between makes and models of the same kind of test equipment.

In maintaining the interface equipment, you will use a vacuum-tube voltmeter, an electronic counter, a signaling test set, a control signal generator (CSG), and an audio oscillator. Some of this same test equipment is used for testing of the base cable plant, which is discussed in Chapter 5 of this volume.

Vacuum-Tube Voltmeter (VTVM). A vacuum-tube voltmeter is used to measure voltage and decibels during the testing of the SF signaling set, line amplifiers, DTMF keyset equipment, and the basic trunk circuit. A decibel is defined as:

- dB—A dimensionless unit for expressing the ratio of two values, the number of decibels being 10 times the logarithm to the base 10 of a power ratio, or 20 times the logarithm to the base 10 of a voltage or current ratio.
- dBm—A unit used to describe the ratio of the power at any point in a transmission system to a reference level of 1 milliwatt. The ratio expresses decibels above or below this reference level of 1 milliwatt.

Measurement of decibels. The decibels meter scale is provided for measuring dBm directly across 600 ohms and for measuring dB for comparison purposes when each measurement is made across the same circuit impedance.

Measurement of voltage. The meter has 2 volts scales: (1) 0 to 1 and (2) 0 to 3. When the range switch is set to .001, .01, .1, 1, 10, or 100 volts, read the 0 to 1 scale. When the range switch is set to .003, .03, .3, 3, 30, or 300 volts, read the 0 to 3 scale.

Audio-Frequency Oscillator. An audio-frequency oscillator is used to provide test tones for the alignment and testing of AUTOVON interface equipment. Special circuitry insures an output voltage of low distortion and high stability with any output load impedance from zero ohms to open circuit.

The model 200CD has three controls for the output. These are the (1) range switch, (2) frequency dial, and (3) amplitude control.

The range, using model 200CD, is selected with the 5-position switch. The position of this switch indicates the multiplying factor for the frequency dial calibration.

The frequency dial varies the frequency between the switch steps. The dial is calibrated from 5 to 60, and its indication multiplied by the range switch factor will give the actual output frequency of the oscillator. This gives us a frequency range of 5 Hz to 600 kHz, covered in 5 ranges. A small knob below the frequency dial is a vernier control for the dial. Study the following examples:

- When the range switch is on the X1K range, and the dial is on 12, the output is 12 kHz or 12,000 Hz.
- When the range switch is on the X100 range, and the dial is on 10, the output is 1,000 Hz or 1 kHz.

> NOTE: This is the test signal normally used in the alignment of the AUTOVON interface equipment.

The amplitude control varies the output power up to 10 volts into a 600-ohm load (20 volts open circuit). For balanced operation, the amplitude control must be set for maximum output (full clockwise). A balanced output may be obtained over the full range of the amplitude control by using a line matching transformer. This is the usual configuration as used in AUTOVON interface.

Transmission Test Set. The 927 A/B is a battery powered, portable instrument with both transmit and receive circuitry. These two circuits may be used independently or simultaneously as required. The 927 A/B is housed in a single lightweight fiberglass case with a removable cover and a carrying handle.

The 927 A/B transmission test set is used in the PABX to check the overall quality of transmission to and from the swithcing center. The purpose of the 927 A/B is to provide a single number rating of the quality of transmission for a voiceband transmission facility. This rating of the quality is a weighted measure of the total amplitude and phase response in the channel. This rating is displayed as a PAR (peak to average ratio) reading on the receive meter and will read between 0 and 100. Perfect transmission (no impairment) is indicated by a reading of 100. Lower readings indicate the presence of some form of impairment. The PAR reading is a significant measure of the pulse waveform distortion and the capability of a transmission facility to reliably transmit signals.

Signaling Test Set. The signaling test set tests the sending and receiving of pulses between the AUTOVON switch and the PABX. This test requires that a test set and people be at both ends of the trunk circuit.

It sends pulses, at one end, at various speeds (PPS) and percentages (make and break) and, at the other end, indicates what is received. The use of this test set is necessary, when setting the bias adjustment of the circuit's SF unit, to correct the percent make-break being received from the distant end. Any pulse-per-second correction will be made by means of a resistor network or adjust relays in the interface trunk circuit.

Control Signal Generator (CSG). This is a compact item not much bigger than a small 5 x 8 card file. It contains a dial, jacks for a headset, two lever switches (two-wire/four-wire, and on-hook/off-hook), three pushbutton switches, and an E lamp and M lamp.

This test set is used to test the indial capability of your equipment. It allows you to test the incoming side of the equipment, with respect to dial pulses, without help from the distant end of the circuit. With it you can test from the two-wire side as well as the four-wire side. When you go to off-hook, the E lamp lights, indicating that the trunk circuit is ready to accept pulses. The M lamp lights when the called party answers, indicating the conditon of the M lead has changed.

Electronic Counter. The electronic counter is a very accurate frequency meter. It is used to check the frequency output of the DTMF keyset, SF units, precise tone supply.

Exercises (821):

1. What is the VTVM used for with respect to interface testing?

2. What is the CSG used for?

3. What uses are made of electronic counter as related to interface equipment?

4. What is the signaling test set used for?

5. What is the advantage of the CSG over the signaling test set?

6. What is the audio-frequency oscillator used for in relation to interface maintenance?

3-3. PMIs and Circuit Alignment

Performing PMIs is nothing more than "looking for trouble." You always hope that you don't find it, but you look anyway.

In Volume 2 of this course we said that PMIs are of different types and performed on a scheduled basis. We also said that the workcard-type tech orders told you what test equipment to use and gave step-by-step procedures for connecting the test equipment and performing the test.

Since this CDC is not intended to replace the tech orders, we do not go into all the PMIs or all the steps contained in any single PMI. We will, however, look at a few PMIs, the test equipment setup procedures, and main steps.

822. Given representative descriptions of malfunctioning equipment operation, determine the type of PMI and test equipment which should be used and indicate why each such approach should be so used.

Our objective here involves accurate performance tests on the basic circuit, DTMF keyset, and the VF line amplifier, four-wire terminating set, and the SF unit.

Basic Trunk Circuit. The testing of the basic trunk circuit requires the use of the following:

- Hand test set.
- Control signal generator (CSG).
- Audio oscillator.
- Vacuum-tube voltmeter (VTVM).
- Pulse repeating test set.
- Operator's headset.
- Capacitor, 0.5 μ f.

Preliminary steps. Once you have the required test equipment gathered, make the following setup:

(1) Before interrupting service by connecting test equipment, get a circuit release from the maintenance supervisor and check at the attendant's position to be certain that the trunk is and will remain idle. Request that the trunk be made busy at the AUTOVON switch to prevent incoming calls during test.

(2) Remove the SF oscillator, SF control unit, and line amplifier associated with the circuit to be tested, if they are accessible. If these units are located outside the PBX interface facility, disconnect their signaling and transmission leads.

(3) Connect an operator's headset to the CSG headset jacks and set the CSG hookswitch to on-hook.

(4) For oversea AUTOVON trunks only: set the CSG two-wire/four-wire switch to the four-wire position. Connect the CSG test leads to the drop side of associated circuit patch jacks, if these are available, or to the distributing frame, as specified in the workcards.

(5) For CONUS AUTOVON trunks only: set the CSG two-wire/four-wire switch to the two-wire position. Connect the CSG test leads to terminal block at the rear of the trunk circuit, as directed in the workcards.

(6) For CONUS AUTOVON trunks equipped with priority diversion circuit: when dialing the number of a PBX extension during these tests, the appropriate precedence digit must be dialed first. For routine calls, dial digit 4; for P0, P1, P2, or P3 precedence level call, dial digit 0, 1, 2, or 3 respectively.

Checking routine NID call processing. To test the trunk for the processing of a routine NID call, do the following:

(1) Set the CSG to off-hook. The E lamp should light.

(2) Dial the number of a local subscriber. A telephone connected to a vacant number on the horizontal side of the frame works just fine for this. A ringback tone should be heard in the headset plugged into the CSG.

When the called party answers, the M lamp of the CSG should light. If the trunk is arranged for attendant transfer, have the extension user depress the hook-switch momentarily; otherwise, proceed to step (7).

After depressing the hookswitch the attendant's routine answer lamp should flash at 120 IPM rate and an audible ringing signal can be heard both by the extension user and in the headset or hand test set.

(3) When the operator answers the flashing lamp, the following should occur: the routine answer lamp goes out, the audible ringing signal ends, and a two-way (or three) conversation with the attendant is possible.

(4) The called party hangs up and the attendant's routine busy lamp goes out momentarily; and the PABX incoming selector releases.

(5) Set the CSG to on-hook. Then the CSG E lamp goes out, and the attendant's supervisory lamp lights.

(6) The operator removes the answer cord. This causes the attendant's supervisory and routine busy lamps to go out, the CSG M lamp to go out, and the CSG E lamp to go out.

(7) The called party hangs up, causing the CSG M lamp to go out.

For this portion of one performance routine only, the CSG was used. You can see that by following these directions, this is no more difficult than routing linefinders.

DTMF Keyset. The tone generator of the DTMF keyset is checked by measuring the output frequency and signal level of each of the eight tones that are generated. To insure greatest accuracy of frequency measurement, the electronic counter is set up to measure the period (reciprocal of frequency) of each tone. The performance standard is expressed in periods, so that the electronic counter readout can be directly compared with the specified performance standard.

This check is made using a VTVM and an electronic counter. After warming them up to assure stabilized operation, check the DTMF keyset as follows:

(1) Connect the VTVM across tip and ring of call cord circuit.

(2) Depress keys 1 and 4 on keyset. The VTVM should indicate −6 dBm (for PABX switchboard where transmission level is +2 dBm).

(3) Disconnect the VTVM.

(4) Connect the electronic counter across tip and ring of the call cord circuit and set the controls on the electronic counter as called for on the workcard.

(5) Press the DTMF keys called for in the workcards and check the counter readout against the millisecond values shown in the workcards.

Two-Wire/Four-Wire Terminating Unit. This unit is checked by applying a known audio signal and measuring resulting signal levels. You need an audio-frequency oscillator, a VTVM, test leads, and terminating plugs. The VTVM is used to measure dB levels of the applied signal and at the test points. Warm up the audio oscillator and VTVM and proceed as follows:

(1) Set the audio-frequency oscillator for 1,000-Hz at 0 dB level and patch into the HYB 2W LINE jack.

(2) Plug a 600-ohm terminating plug into the HYB REC DROP jack.

(3) Connect the VTVM, terminated in 600 ohms, to HYB TRSG DROP jack. The VTVM should indicate greater than -16 dBm.

(4) Disconnect test equipment.

(5) Set audio-frequency oscillator for 1,000-Hz at +7 dB level, and ocnnect to LINE REC DROP jack.

(6) Plug a 600-ohm terminating plug into HYB 2W DROP jack.

(7) Connect VTVM, terminated in 600 ohms, to HYB REC LINE jack. The VTVM should indicate 0 dBm.

(8) Disconnect test equipment.

Exercises (822):

Use the text and necessary foldouts to determine the type of PMI and test equipment used to checkout trouble described below and state why you would do it that way.

1. The operator on position 2 complains that she gets wrong numbers everytime she uses the AUTOVON trunks.

2. While performing a type 1 PMI on the hybrid you find that the levels observed are not the same as those called for in the tech order.

823. Using the text and appropriate foldouts as necessary, identify the test equipment required to test and align the precise tone supply, DTMF keyset, VF line amplifier, and SF signaling unit.

With the high priority type of AUTOVON traffic and circuitry involved in the interface equipment, proper alignment of all associated equipment (precise tone supply, DTMF keyset, VF line amplifier, and SF signaling unit) cannot be too highly stressed.

Let's take a look at the various pieces of equipment involved and what test equipment will be required to adjust it.

Precise Tone Supply. The precise tone supply generates the preempt tones used to notify a subscriber that he has been preempted by the switchboard.

While performing PMIs you may discover that the precise tone supply requires adjustment. The adjustment procedures are outlined in the PMI workcard set and technical order that apply to it. You would use the electronic counter, VTVM, and instructions in the appropriate TO and workcard set to readjust the precise tone supply to meet standards.

DTMF Keyset. The DTMF keyset provides the frequencies used to make precedence calls from the switchboard. This unit is normally properly aligned during manufacture, but may require readjustment after initial installation or as components age during use. PMIs are performed on the unit at regular intervals, and if a discrepancy is noted it would be your job to readjust the DTMF unit to specifications. To do this you would need the TO for the DTMF keyset, an electronic counter, DC power supply, and nonmagnetic alignment tool. The DC counter would be connected as shown in figure 3-5 and adjustment made as outlined in the TO.

VF Line Amplifier. Alignment problems in the VF line amplifier will normally show up during operation. Before attempting to readjust the VF line amplifier you should insure that all distant end, near end conditioning equipment, and the transmission facility associated with this circuit meet all transmission criteria. If all transmission criteria are met and you are sure that the VF line amplifier needs adjustment, you will have to get assistance from personnel at the far end or, if your equipment goes through a tech control facility they will help in setting the levels. You will need an audio-frequency oscillator, VTVM, test leads, terminating plugs, and the appropriate TO. You would adjust the RCV. EQUAL, RCV LEVEL, XMIT EQUAL, and XMIT LEVEL as required to get the proper levels and prevent echo and singing in the circuit.

SF Signaling Units. The SF signaling units may or may not be located in the central office, depending on your location. Chances are if you are in the states your office will not have the SF signaling units, they will be located in and maintained by the local civilian telephone company. If you are overseas, the SF signaling units will most likely be in your office, and in this case you will have to maintain them. As with the VF line amplifier, before you make any adjustment on the SF units, you should make sure that they are at fault and that there is not some other trouble with the distant end, near end, or transmission facility.

If the SF units are at fault and require adjustment, you will need help from the distant end or tech control facility, the appropriate TO, a signaling test set, VTVM, audio-frequency oscillator, terminating plugs. electronic counter, and amplifier. Once you have it all together follow the instructions in the TO and make the necessary adjustments.

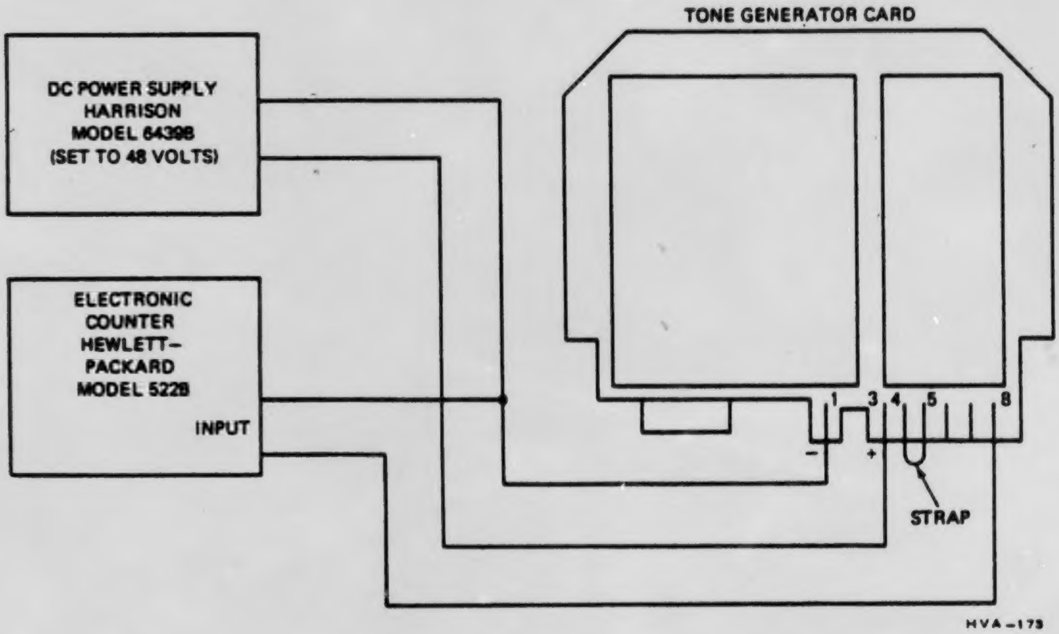

Figure 3-5. Tone generator card alignment—test equipment connections.

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Exercises (823):

1. What test equipment is required to adjust the precise tone supply?

2. The DC power supply is used when adjusting the ______ ______.

3. The AC amplifier is used when adjusting the ______ ______ ______.

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CHAPTER 4

Base Wire System

TO THIS POINT this volume has been concerned with the operation and maintenance of interface equipment and circuits. This chapter will provide information on the transmission lines over which information is delivered.

4-1. Cable Plant Makeup

An understanding of cable map makeup is hardly possible without an awareness of both the symbols employed to indicate on cable maps the various components of the cable plant and the designators used to represent on these maps cables and cable terminals. This section will discuss these symbols and designators.

824. Using figure 4-1 as necessary, state the categories of cable plant, identify symbols used on cable maps to represent cable plant components, and differentiate underground from buried cables.

"Cable plant"—exactly what is the meaning of this term? The term is generally used to refer to all outside telephone cables associated with one particular telephone system or central office. However, due to the many and varied types of cables involved in a system, more specific terms are required. Consequently, the overall cable plant is divided into categories. These categories are, in turn, divided into parts. The two main categories are (1) "trunk plant" and (2) "distribution plant." Trunk cable plant is broken into two parts—(1) "trunk cables" and (2) "interlocal trunk cables." Trunk cables have both ends terminated in central offices. Usually trunk cables connect a base telephone system with an outside commercial telephone company. Interlocal trunk cables are main communication arteries between offices within the base administrative telephone system.

Cable distribution plant consists of three parts: (1) feeder cables, (2) branch feeder cables, and (3) distribution cables. You will find figure 4-1 very useful as you examine the rest of this text segment:

- Feeder cables serve as a connection between the central office and large areas or several base functional areas.
- Branch feeder cables connect main feeder cables to individual base functional areas.
- Distribution cables connect main feeder cables or branch feeder cables to distribution terminals from which connection is made to telephone sets by means of a drop, block, or station wires.

In addition, cables within each part of the plant are typed according to the kind of construction used for their installation. Thus there are five main types—underground, buried, aerial, block, and building cables.

Underground Cable Plant. Underground cables are those placed in a fixed underground conduit system. Underground cable is less susceptible to damage than is any other type of cable plant. It has the advantage of very high flexibility between cables in the same conduit run, since all splicing is done in common manholes. Also, cables which are no longer required may easily be removed with a high degree of salvage possible, and the duct thus released may be reused without any cost for rehabilitation.

The manholes associated with the underground cables offer the ultimate in physical arrangement of the cables for splicing purposes (under all weather conditions) and for the installation and maintenance of load coil cases or pressurized system apparatus.

Underground cable is used mostly in main feeder routes, and to a lesser degree in branch feeder routes. The use of underground cable and conduit is preferred when full size cables (cables approximately 2 inches in diameter, or 5 pounds per foot) are required, and also when more than two cables are to be placed on a pole line or are to be buried. This type of plant is also preferred when the possibility of damage to aerial or buried cable plant exists.

On a plant map, underground cable will normally be represented by solid heavy lines. Rectangles along the lines will represent manholes.

Buried Cable Plant. Buried cables are those cables placed underground, but not in an underground conduit. They may be placed in trenches dug for that purpose, or placed by means of special plows. When buried cables are laid in trenches, various types of physical protection (beside that offered by the protective covering of the cable) may be placed to prevent damage from other underground construction. Even buried cable is more susceptible than underground cable to both physical and

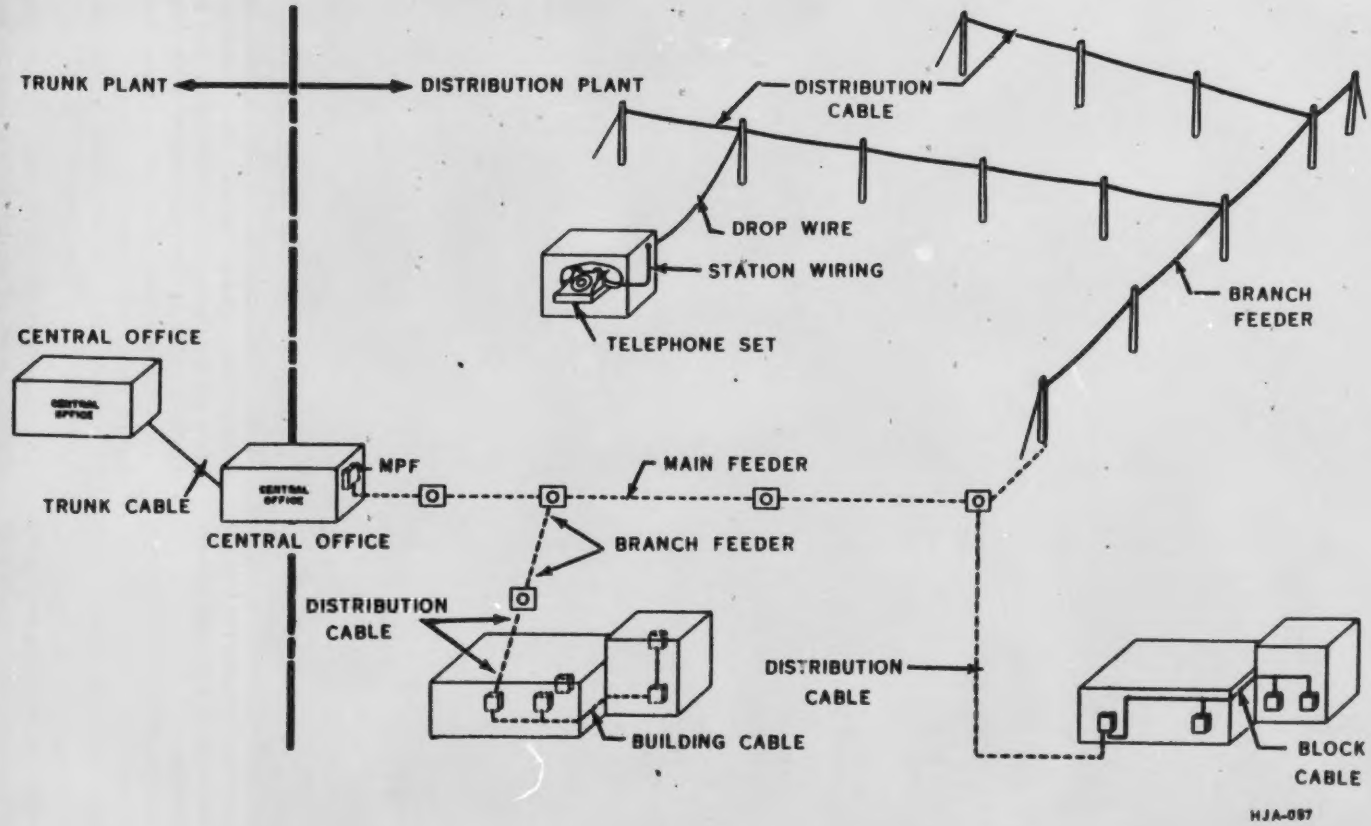

Figure 4-1. Typical cable plant construction.

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electrical damage. Buried cables may be spliced in manholes or permanent splicing pits. They may also be spliced in the trench or plow run and directly covered with earth. Buried cables are relatively inflexible between cables. However, they do have the advantage that branch cables may be spliced to them at any location.

Buried cables may be used as main feeder and branch feeder cables where only one or two cables will ultimately be required. In this case, permanent splicing locations are used. This set up can also be used where conduit construction must be deferred or cannot be completed in time for use. In this latter instance, permanent manholes at correct spacings are installed, and the buried cables are spliced in these manholes. The buried cable run is parallel to and slightly to one side of the proposed conduit run between the manholes. Buried feeder cables placed in this manner may be continued in use after the underground type of plant is completed and in use. Buried cables find their greatest use in long runs where distribution is extremely limited, such as the remote control and operation of nontelephone communication equipment or trunk cable usage. It also finds use in distribution plant where the plant must be placed underground to avoid physical hazard or damage or for better appearance, and the cost of underground cables and conduit cannot be justified.

The accepted standard symbol for showing buried cable on a plant map is an evenly broken line. The rectangular symbol for a manhole may also appear with this type cable installation.

Aerial Cable Plant. Aerial cable plant consists of cables supported on poles by a suspension strand. Aerial cable plant is more susceptible to damage, both physical and electrical, than is either underground or buried plant. The cost of aerial cable plant and associated pole lines is less than that of underground cables and conduit, but greater than that of buried cable plant if the pole line is not already available.

Aerial cable plant is used mostly where the distribution at each service location is small and may be accomplished by means of drop or block wiring. It may also find use on branch feeder or trunk cables where distribution branches are infrequent. In general, no more than two aerial cables are placed on a single pole line. Also, cables larger than 2 inches in diameter or weighing more than 5 pounds per foot are not used in aerial plant unless the cost of underground or buried cables is prohibitive.

Aerial cables are commonly shown on a plant map by a solid line. Adjacent to the solid line are circles or round dots to indicate the supporting poles.

Block Cables. These cables are essentially an extension of underground, buried, or aerial cables into the interior of a block of buildings where, in most cases, they are attached to the rear outside walls of the buildings. Such installations are usually made to building blocks where the telephone service requirement is large, such as hospitals, shops, headquarters, etc.

Building Cables. These are cables extending from the cable plant outside the building to a main terminal or frame within the building and/or are distribution cables run inside a building.

The difference between block and building cable is also evident in figure 4-1. As you can see, the block cable serves several buildings and is placed on the outside; the building cable serves the inside of one building. Distribution cables, of course, may be installed with any one or any combination of the five types of construction.

Exercises (824):

1. What are the two categories of cable plants?

2. On a cable plant map, how are underground cables identified?

3. What are the differences between underground cables and buried cables?

4. On a cable map, how do you distinguish between aerial and underground cables?

825. Using figures 4-2 and 4-3 as needed, identify those designators used on base cable maps for cables and cable terminals.

A base cable map depicts the following information:

(1) Location of the central office.

(2) Boundary limits of the installation.

(3) Location of buried cables.

(4) Location of aerial cables, including the side of street on which they are installed.

(5) Underground conduit system with manholes placed and numbered to correspond to the underground conduit record. Main underground cables are not shown on the outside plant map but are shown in detail on the underground cable diagram.

(6) Open wire leads, if they are an extensive enough portion of the communications system.

(7) Aerial and buried cables which are not Government owned are labeled "TELCO."

An underground cable record, using standard symbols, shows all the underground telephone cable installed in a particular conduit system section of an Air Force installation. This record may consist of one or more sheets to schematically indicate the entire underground cable system. This includes vault, manholes, service boxes, and buildings connected with underground service cables. An underground cable record drawing contains the following data:

(1) The number and arrangement of ducts between manholes with cable numbers indicating the duct in which each cable is located.

(2) Manholes and manhole numbers.

(3) Size of cable and gage of wires, including stubs.

(4) The pair count of pairs within a cable, including the indication of dead pairs.

An aerial, buried, and block cable record will show only the information related to these three types of cable plant. This diagram indicates all such cable lines on a street plan background and shows:

(1) Number, size, gage, and pair count of each cable including all main, branch, distribution cables, and cable stubs, and also the location and pair count of all main cable terminals.

(2) Location of loading coil cases, including the number and type of coils with the pair count of the pairs to which they are spliced.

(3) Cumulative length of each cable measured from the tip cable termination midpoint on the MDF to the center of each terminal splice on each aerial, buried, block, or building cable, or to the end of each stub.

(4) Location of pressure testing valves, plugs, bypasses, contactors, and contactor terminals.

More important than knowing the physical location of the cable installation is the ability to identify the cable numbers and cable pairs for particular lines. Figure 4-2 shows how cables and pair groupings are identified on maps. Study these symbols and the explanations thoroughly. During cable plant test procedures it will be necessary for you to determine the wire sizes, the cross connects and length of the line to the test point.

Main, branch, and feeder cables directly connected to the central office mainframe are assigned numbers from 01 to 99. All such cables will, therefore, have a two-digit number designation. Figure 4-3 illustrates the five basic rules of the cable numbering system:

(1) A distribution cable (aerial, buried, underground, building) spliced directly to a main or branch feeder cable is numbered the same as the associated feeder cable.

(2) A distribution cable cross-connected to a main or branch feeder cable is designated with the suffix 01, 02, 03, etc., as appropriate. The numerical sequence of the suffixes is dependent upon the date of placement of the distribution cable. Thus, the first distribution cable connected to the main cable numbered 02 through a cross-connecting terminal is numbered 0201. The pair count in the cross-connected distribution cable will always begin with pair number 1, regardless of the pair count on the central office side of the cross-connecting terminal.

(3) A distribution cable connected to a main or branch feeder cable through a straight-connecting terminal is numbered as defined in rule 2, but its pair count will be the same as the pair count of the feeder cable.

(4) A distribution cable connected to a main or branch feeder cable through more than one cross-connecting terminal retains the number of its associated feeder cable but adds a two-digit suffix for each cross connection.

(5) Where two or more distribution cables are connected to a main or branch feeder cable through one or more cross-connecting terminals, the cross-connected cables are numbered the same as the feeder cable with suffixes 01, 02, 03, etc., as necessary. The numerical sequence of the suffixes depends upon the order of placement of the cables.

The terminal numbering system for aerial cables is coordinated with the pole numbering system; each cable terminal will bear the same serial number as its supporting pole with a prefix T added (T-A1-2).

Each direct-connected terminal on or within a building will bear the number of that building and a prefix T. If a cross-connecting terminal is involved in the building cable installation, it should bear the number of that building with a prefix T and the suffix 1. An example of this would be T-14-1. The building cable terminals on the distribution cable beyond the cross-connect terminal should carry the same building number with the suffixes 2, 3, 4, etc. (T-14-2).

Exercises (825):

1. What numbers are used to designate main, branch, or feeder cables that connect to a central office main frame?

2. How is a cross-connect to a main feeder designated?

3. What does the number 1-101 below a designated cable represent?

4. How is a terminal on a building represented?

5. How are aerial and buried cables not belonging to the Government identified?

4-2. Telephone Transmission Lines

Certain significant factors are responsible for the loss of signal strength over telephone transmission

SYMBOLS AND ABBREVIATIONS FOR TYPES OF CABLE

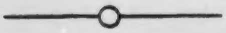
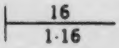
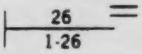
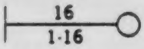
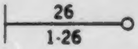
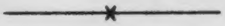
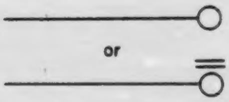
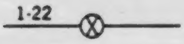
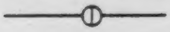
Symbol	Explanation
	Cable, all types
6X-19	6-pair No. 19 gauge cable (If less than a 26-pair cable add "x" to designation of size)
26-22	26-pair No. 22 gauge cable (If 26 pairs or more, and less than 101 pairs)
151-19	151-pair, No. 19 gauge cable (If nonstandard sizes larger than 101 pairs)
9-22	909-pair, No. 22 gauge cable (If 101 pairs or multiples of 101 pairs)
51-19 101-22	253-pair, composite lead covered cable, consisting of pairs and gauges as indicated
101-24 26-22 SC	26-pair, No. 22 gauge silk and cotton insulated cable
P26-24P	26-pair, No. 24 gauge plastic sheathed, plastic insulated cable (Prefix indicates sheath material if other than plain lead; suffix indicates insulation material if other than paper)
72Qd-19 Subm. 129Pr-22	273-pair, composite submarine cable with quads, pairs and gauges as indicated
26-19 TA 152-22 202-24	380-pair, composite tape armored cable with pairs and gauges as indicated
— 3-22 →← 2-22 —	Double arrow indicates change in cable line. Change in code indicates type of change: size, gauge, change from underground to aerial, change in count, change of type of cable, or any combination of these (Example shows change from 303 pairs, No. 22 gauge to 202 pairs, No. 22 gauge)
	Existing splice (Shown only when splice would not otherwise be apparent)
 16 1-16	Outside distributing terminal - unprotected - all types (Upper figure indicates capacity of terminal; lower figure, pair count of cable circuits terminated)
 26 1-26	Outside distributing terminal protected by carbon blocks only
 16 1-16	Outside distributing terminal protected by fuses only
 26 1-26	Type UG-16 cable terminal for underground distribution (Note smaller circle)
	Outside cross-connecting cable terminal without carbon blocks or fuses
	Inside distributing cable terminal - binding post chamber type - with fuses and carbon blocks (Horizontal line above symbol for the terminal symbol indicates protector block equipment mounted in, or part of a terminal - circle indicates fuse type of protection)
 1-22	Outside cross-connecting cable terminal with fuses (Numerals indicate pairs in cable)
	Inside straight-connected cable terminal with fuses - binding post chamber type

Figure 4-2. Drawing symbols.

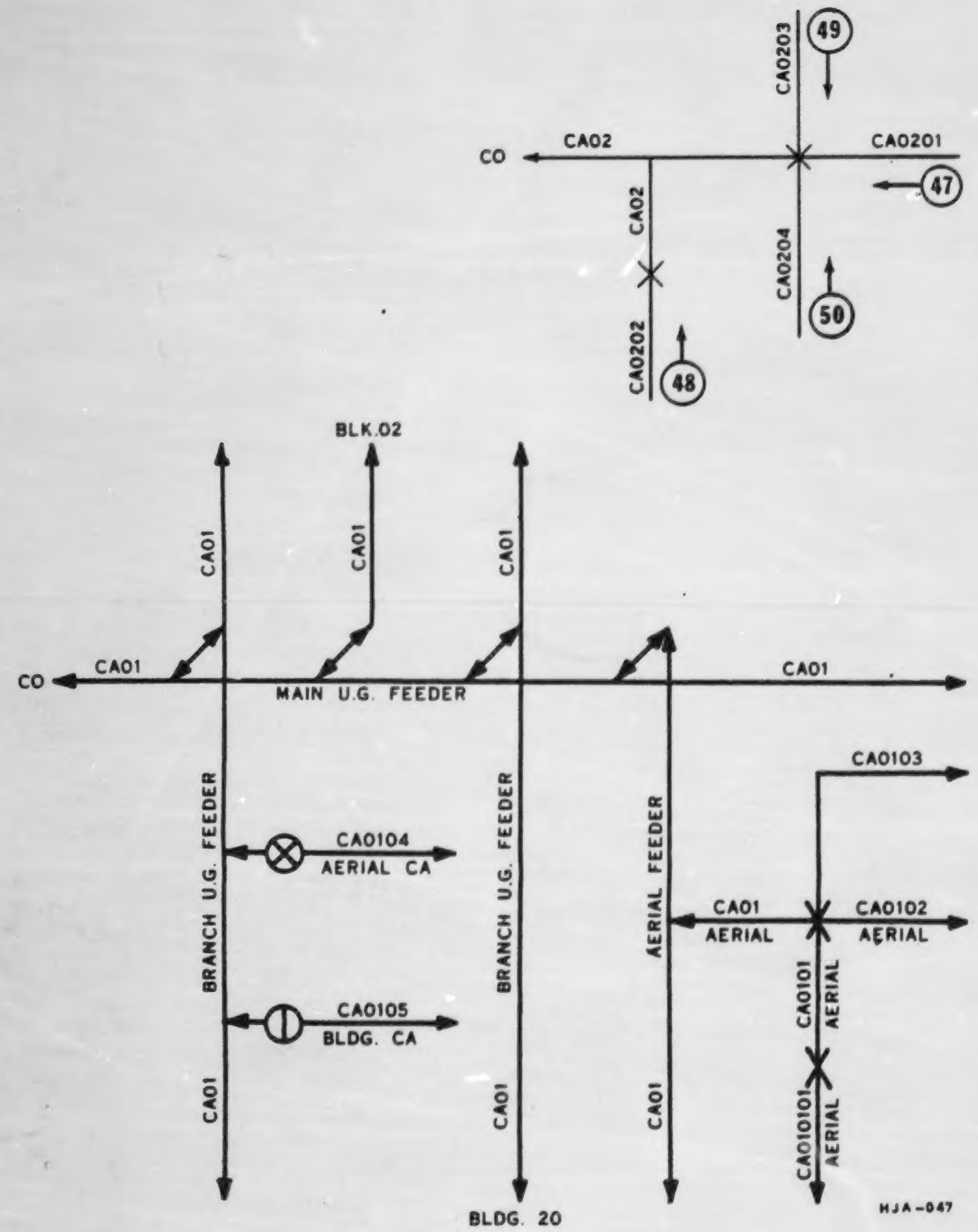


Figure 4-3. Cable numbering

lines. We will try to identify these factors in this section.

826. Using figures 4-4 through 4-11 as required, distinguish among the factors that cause a loss of signal strength on telephone transmission lines.

Line Characteristics. The primary purpose of establishing telephone lines is the transmission of voice currents from one station to another. This talking circuit, or transmitting circuit, consists of these three essential factors:

(1) A source of energy.

(2) A medium over which it is desired to transmit energy to a receiving device.

(3) The receiving device itself which converts the energy into the form desired.

Applying these factors to a telephone talking circuit from station to station, the transmitter is considered the source of energy (although it does not actually generate any energy), the line from the calling station to the called station (conductors) is the medium over which energy is transmitted, and the receiver at the called station is the receiving device. The voice currents are in the form of moving waves, and they encounter opposition at every point of the medium over which they travel until they reach the distant end. This opposition tends to dissipate the energy or cause it to be reduced. Such loss of energy by the voice currents, which is really a reduction in their strength, is called attenuation. This loss or reduction in strength is caused by capacitance, inductance, and resistance.

The loss in power, as described, is called the *transmission loss* and can be measured with the aid of a transmission measuring set. This loss is really the ratio or relation between the inputand the output, or a comparison of volume of input at the transmitter with the volume of the output at the receiver, at the distant end. The unit of transmission loss is the decibel, abbreviated dB. The majority of talking circuits should have a decibel loss of less than 30 in order to provide satisfactory transmission. Long trunk and toll cables use various types of boosters, repeaters, and loading coils to overcome transmission loss.

When a generator is connected directly to a power consuming load, the load may be represented as a simple resistor. The reason for this is that only the resistance of the load is capable of dissipating the power. The power consumed in the resistor is equal to the power supplied by the generator. Assume that the same power-consuming device is connected to the generator by means of a long transmission line. It is now found that the power consumed by the load is less than the power supplied by the generator.

Thus, the transmission line has characteristics that cause power dissipation (loss) between the transmitter and the load. This power dissipation does not take place at any one point but occurs equally along the entire length of the line. The electrical characteristics of the line that cause the power loss are distributed uniformly over the entire length of the line. For this reason, they are called the *distributed constants* of the line. If the power dissipation took place at distinct points on the line because these characteristics were concentrated, as a coil concentrates inductance or a capacitor concentrates capacitance, they would be called *lumped constants*. There are four distributed constants: series resistance, series inductance, shunt capacitance, and shunt conductance (more commonly known as *leakage*); all are measured per unit length of transmission line.

Series resistance. The total resistance of a transmission line is found by multiplying its series resistance, per unit length, by the total length of the line. Thus, if the series resistance of a line is 10 ohms per mile, and the length is 100 miles, its total resistance is 1,000 ohms. The distributed resistance of a transmission line depends upon the size (gage) of the wires and the frequency of the traveling wave. The resistance increases as the diameter of the wire decreases. It is given the symbol "r" and is expressed in ohms per loop mile. A loop mile is the total length of both lines between two points 1 mile apart. Thus, a loop mile of line is 2 miles long, and the resistance in ohms per loop mile is twice the resistance of one conductor per mile. One half of resistance per loop mile may be represented in an equivalent circuit, shown in A, figure 4-4, where half of it is considered to be lumped in series with each wire; or the total may be represented in B, as concentrated in one conductor only.

Series inductance. Self-inductance is that property of a circuit which causes a counter-voltage to be induced in the circuit by a change in the current in the circuit. In a transmission line through which a changing current is flowing, a voltage is induced along the line. This indicates that series inductance is distributed over the entire length of the line. The magnitude of this series inductance is determined by the size of the wires and their separation. It increases as the center-to-center distance between the wire increases and as the diameter of the wires decreases.

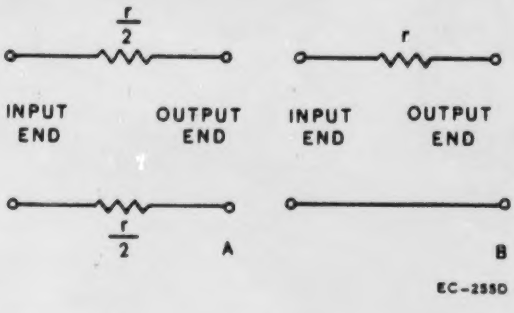


Figure 4-4. Distributed series resistance.

The distributed inductance is given the symbol "l" and is expressed in henrys per loop mile. The total inductance per loop mile may be represented also in two halves, each half representing the inductance in one of the two conductors, shown in A, figure 4-5, or it may be considered as concentrated in one conductor, as in B. The series inductance of a transmission line causes an opposition to the alternating voice currents in the form of inductive reactance. Inductive reactance, X_L, is a function of frequency and is expressed by the formula $X_L = 2\pi fL$. Therefore, as frequency increases, the inductive reactance or opposing effect also increases.

Shunt capacitance. A capacitor consists of two metallic conductors separated by a nonconducting substance, such as air or some other dielectric. The capacitance is large when the area of the conductors is large, as in the case of two flat plates, and the capacitance increases when the distance between the plates is made smaller. In a capacitor, the separation of the plates deliberately is made a small fraction of an inch. A transmission line also consists of two metallic conductors separated by a dielectric. As a result, the line capacitance is distributed over the entire length of the line. However, the area of the surface of a length of transmission line is much less than the area of a conventional capacitor plate and the distance between the lines is much greater than the separation between the plates of a capacitor, so that the distributed capacitance of a transmission line is much less than the lumped capacitance of a capacitor. In the transmission line, the distributed capacitance appears between the adjacent wires and is called the *shunt capacitance*. The shunt capacitance per unit length is determined by the size of the wires, the distance between the wires and the nature of the dielectric material between them. The capacitance increases as the diameter of the wires increases, as their center-to-center separation decreases, and as the dielectric constant increases. The distributed capacitance is given the symbol "c," is expressed in farads per loop mile, and is represented by a capacitor shunted across the two conductors, illustrated in figure 4-6. The important thing to keep in mind is that the distributed capacitance causes capacitive reactance to develop across or in shunt with the transmission line. This causes a shunting of voice-frequency currents across the line, and the result of this is that less voice-frequency energy reaches the receiving end. Since capacitive reactance decreases as the frequency increases ($X_C = \frac{1}{2\pi fc}$), the shunting effect and loss becomes greater as the frequency increases.

Shunt conductance. Because the dielectric between the two wires of a transmission line is not a perfect insulator, a leakage current exists between the two. The dielectric separates the wires of the transmission line over its entire length, so that leakage exists at every point along the line. In an open-wire line the dielectric between the conductors is air. Although dry air is an almost perfect insulator, outdoor air is seldom dry, and its conductivity increases greatly in damp weather. In cables the dielectric consists of the insulation around individual conductors. The best of insulators conduct extremely small amounts of current. Although cable leakage is unaffected by dampness of the outdoor air (which is excluded by the outer and inner covering of the cable), it does vary somewhat with temperature. Since the leakage takes place through a conducting path between the wires, this corresponding line characteristic may be called *shunt conductance* or *leakage*. It is given the symbol "g," is expressed in ohms per loop mile, and is represented as a resistance between the two wires, as shown in figure 4-7. Note that line leakage acts as a shunt to the flow of voice-frequency currents in the transmission line, and as a result, current shunted across the line cannot reach the receiving terminal.

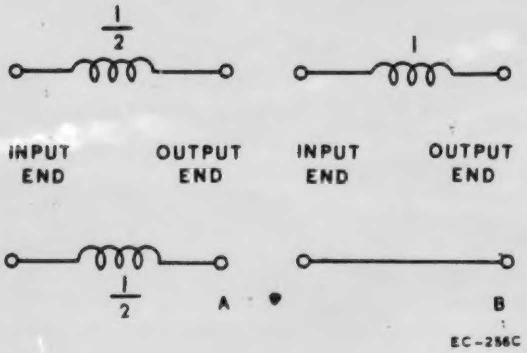


Figure 4-5. Distributed series inductance.

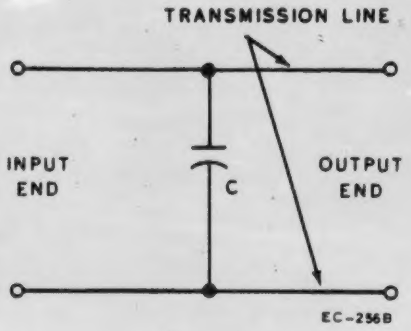


Figure 4-6. Distributed shunt capacitance.

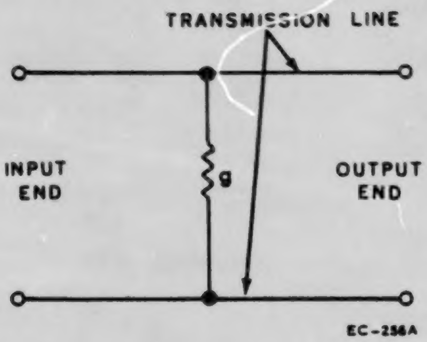


Figure 4-7. Distributed shunt conductance.

Equivalent network. A unit length of transmission line or line section, 1 loop mile of line, may be represented for convenience as an equivalent network composed of all four distributed constants of the actual line, as seen in figure 4-8. Three alternative representations of the actual line section are shown. The equivalent tee section in C is formed by placing the series constants (resistance and inductance) in one line, half on each side of the shunt constants (capacitance and conductance). You must remember that, in figure 4-8, the lumped elements r, l, c, and g are merely convenient representations of properties that are actually distributed over the whole length of the section. Their values are such that they would have substantially the same effect on a transmitted signal, and on any circuit connected to the line section, as the actual distributed constants of the section. A transmission line more than one section long may be made by connecting two or more unit line sections, as seen in figure 4-9. The electrical behavior of the line then may be studied by analyzing the behavior of the equivalent network.

Characteristic impedance. The distributed constants of a transmission line determine its operating characteristics, which, in turn, affect the signal being transmitted over the line. The most important of its operating characteristics is the characteristic impedance, Z_0. The characteristic impedance of a transmission line is a property of the line itself, dependent only on its distributed constants. It is entirely independent of the length of the line, the internal impedance of the generator supplying the line, or the load placed across the terminals of the line.

Power Transfer. The primary purpose of a transmission line is to transfer a maximum amount of power to the receiver at the receiving end of the line. The maximum power transfer occurs when the input impedance of the receiver and the internal resistance of the generator are equal to the characteristic impedance of the transmission line. For this reason, the value of characteristic impedance of a transmission line is important.

Consider the circuit illustrated in A, figure 1-10; this shows a generator delivering power to a 600-ohm load. Let the internal resistance of the generator be 600 ohms and let its voltage be 120 volts. Calculations will show that the total output power of the generator is 12 watts, and that the power delivered to the 600-ohm load (receiver) is 6 watts. In B, the load resistor is changed to 300 ohms, causing the output power of the transmitter to change to 16.0 watts, and the power to the load is changed to 5.33 watts.

The values of the power delivered to the load resistor calculated in the paragraph above, supplemented by others to make a smooth curve, are plotted in the graph of figure 4-10. The graph shows the maximum power is transferred from the transmitter to the receiver when the internal impedance of the transmitter and the impedance of the load are equal. This conclusion is related to the characteristic impedance of a transmission line as

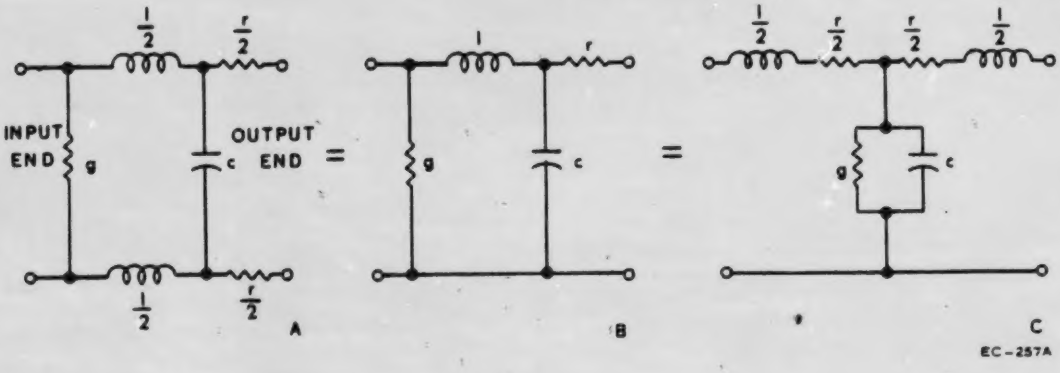
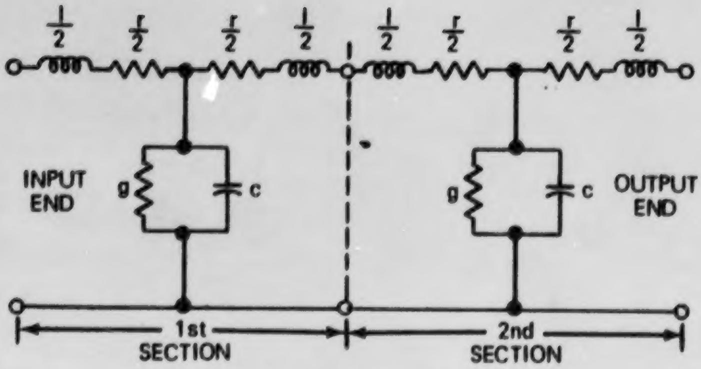
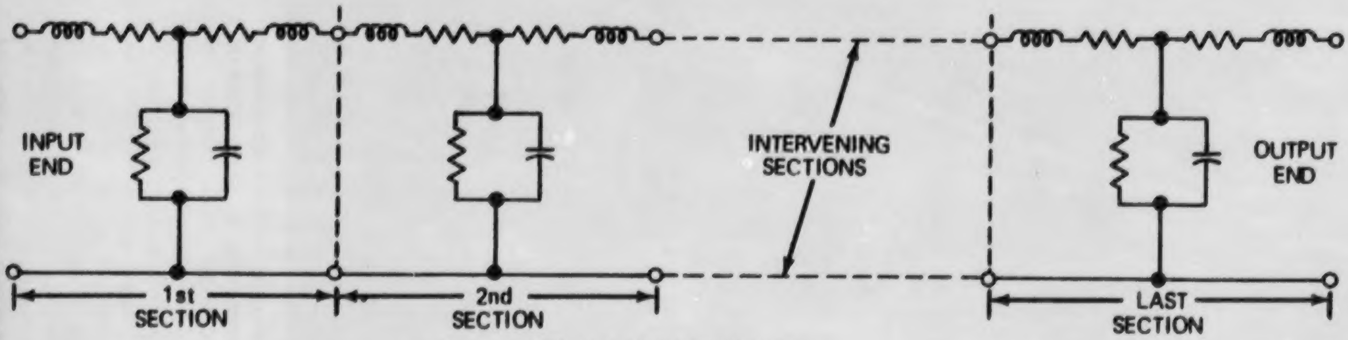


Figure 4-8. Line section of unit length.

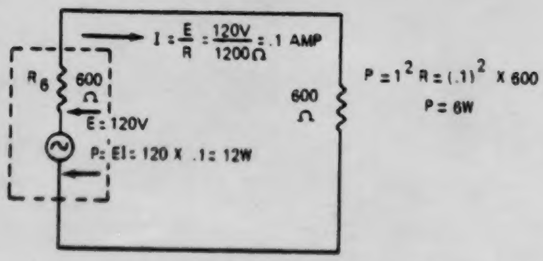


A. TWO SECTION LINE LENGTH

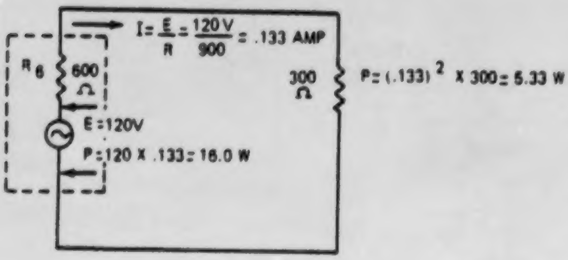


B. LONG TRANSMISSION LINE

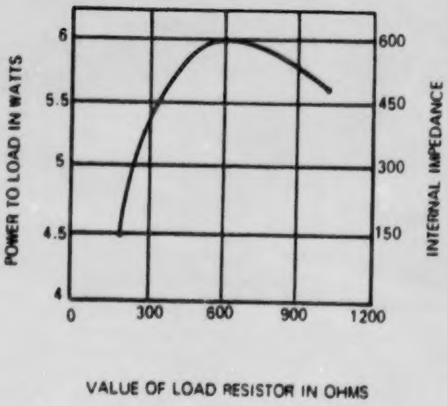
Figure 4-9. Equivalent network of transmission line.



USING A 600 OHM LOAD RESISTOR A



USING A 300 OHM LOAD RESISTOR B



C

EC-258

Figure 4-10. Generator operating into variable load.

follows: to the transmitter supplying power to a transmission line, the line is the load; consequently, the generator will deliver maximum power when its internal impedance is equal to the input impedance of the line.

At the receiving end, the line acts as the generator delivering power to the load. The internal impedance of the line is its characteristic impedance. Therefore, it will deliver maximum power to the load when the load impedance is equal to the characteristic impedance of the line. Thus, a 600-ohm line should be terminated by a 600-ohm load and supplied from a 600-ohm transmitter. The maximum power tranfer takes place at both ends of the line, and therefore, from the actual generator to the actual load. Under this condition, the generator and the load are said to be matched to the line.

Attenuation. Attenuation of a wave is the decrease in amplitude which accompanies its propagation or passage through equipment lines. Degree of attenuation is commonly measured in decibels or dB per loop mile of transmission line. Someof the reasons for attenuation are the different line characteristics we have been talking about, such as series resistance, shunt capacitance, series inductance, and impedance mismatching. These constants of the line cause power loss of the signal, which means that the signal is not as strong as the receiving end as it was at the originating source.

Loading. A loading coil in wire communications is used to add inductance to a transmission line for the purpose of decreasing power losses and providing equal response over a given frequency range. Loading coils are inserted at equal distances along a transmission line. The adding of loading coils reduces both attenuation and frequency distortion. There are two types of loading that have been used—(1) lumped and (2) continuous loading. Lumped loading is used in the military and will be discussed in greater detail shortly. Continuous loading is when a material is wrapped around the outside of the cable to give the line distributed constants. An example would be in submarine cable, where the cable is under water and the different loading coils would not be able to be distributed correctly.

To better understand the principles of loading as applied to telephone cable circuits, let us consider a mechanical analogy. As shown in figure 4-11, a piece of light string, say about 10 feet long, is fastened to a hook in a wall. It can be compared to a cable pair. By a snapping movement of the hand, waves of motion are generated in the string. They tend to die out rapidly before traveling to the end of the string. If a heavier string were used, the waves would be propagated a little longer distance along the string before dying out. The heavier string may be considered analogous to a larger gage wire which has a lower resistance.

Let us tie a small lead weight, like that used on a plumbline, to the center of the string. The waves created in the string by the snapping movement of the hand will again decrease rapidly. In fact, the waves will cease when they reach the weight. This illustrates

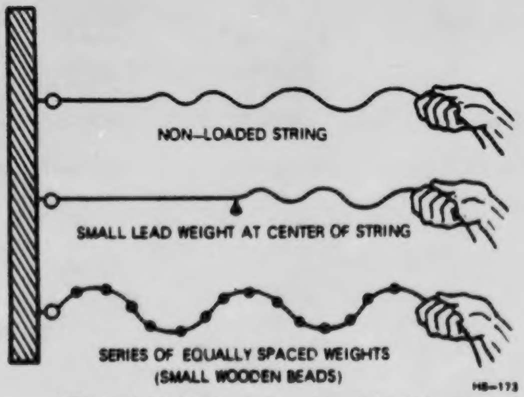

NON-LOADED STRING
SMALL LEAD WEIGHT AT CENTER OF STRING
SERIES OF EQUALLY SPACED WEIGHTS
(SMALL WOODEN BEADS)
HB-173

Figure 4-11. Mechanical analogy of loaded cable.

that a large amount of loading cannot be added to a circuit at one point. Now, let us take about 20 small wooden beads or similar light weights and space them equally along the entire distance of the string and tie them. When the string is now snapped, the resultant wave motion will travel the entire distance of the string to the wall hook with only a slight decrease amplitude. This analogy shows that proper loading reduces the attenuation and distortion in a cable circuit.

The combination of the distributed capacitance and the lumped inductance of the loading coils causes a loaded cable circuit to act like a bandpass filter. This effect greatly increases the attenuation of the cable when the cutoff frequency is exceeded. This cutoff frequency is determined by the capacitance of the cable and the inductance of the loading coils. By installing proper loading coils and spacing them at certain prescribed intervals, the cutoff frequency can be increased beyond the upper end of the frequency band to be transmitted.

There is a practical limit to the number of loading coils that can be inserted into a cable circuit. Each loading coil increases the series resistance of the cable conductors. This added resistance would soon overcome the beneficial effects of loading coils that can be inserted into a cable circuit.

Note that the conductor resistance increases and the cutoff frequency decreases as the inductance value of the loading coil is raised. In addition, when the loading coil spacing is cut in half, the frequency range of the cable circuit is extended by about 40 percent or more. Loading, furthermore, reduces the propagation velocity in cables. The added inductance due to loading diminishes the speed of travel of the voice and carrier currents in a loaded cable.

Exercises (826):

1. What line factors will cause a greater attenuation of a high-frequency signal than of a midband signal?
2. What two factors affect the amount of inductive reactance in a transmission line for a signal of a given frequency?
3. What cause of line loss would increase if moisture got into a cable?
4. What two causes of line loss would be increased by using cable with a smaller wire diameter?
5. When does maximum power transfer to the far end of a cable occur?
6. Why are loading coils connected to telephone transmission lines?

4-3. Factors Affecting Line Quality

Many properties of a telephone line affect how well the signal received at the far end resembles the input signal. Here we will limit our coverage to those factors the inside plant man can measure or correct. These are noise and distortion.

827. Provide the specific causes of noises and point out selected ways of reducing noise on different kinds of telephone transmission lines.

Types of Noise. Now that you have studied the different types of cables and cable plants and transmission line principles, let's discuss the types and sources of noise that affect transmission on a cable, be it telephone, teletype, audio, or high speed data.

Electrical noise can be generally defined as any undesirable electrical energy which is present in a circuit or system. This undesirable energy can be either AC or DC or a combination of both in any form. Many varieties of noise exist, but all can be classed according to the several general categories taken up next.

White noise. Noise is generated in the flow of electricity through a conductor as electrons collide with some of the molecules of the conducting material. Any increases in temperature cause corresponding increases in the amount of noise. The various types of noise based on thermal agitation or radiation are sometimes called (1) resistance noise, (2) thermal noise, (3) Johnson noise, or (4) white noise. Such "white noise" is normally more prevalent on radio-derived circuits than on exclusively wire circuits. The relatively even distribution of white noise with frequency means that it is not usually a serious source of interference to data transmission, unless it causes the signal-to-noise ratio to fall to an unacceptable level.

Hum. "Hum" can be defined as any low-frequency, recurring, nontransient, electrical disturbance in a communications system which is not associated with actual signal energy. Normally, hum has a direct relationship to equipment power supply ripple or inductive/capacitive coupling to AC powerlines. Where telephone cables are near high voltage AC power distribution systems, harmonic energy may be coupled into the telephone cable pairs.

Impulse noise. "Impulse noise" is the result of discrete dusturbances having abrupt changes of short duration. These disturbances are often of relatively high amplitude and of short duration; they may or may not be periodic. Although data signals can stand relatively high steady state noise, because of their short symbol intervals, they are greatly impaired by impulse noise. It may lead to errors and possibly disruption of communication; for example, by interference with timing signals or by degradation of the signal to noise ratio. Impulse noise in Government owned circuits is very often caused by high level, switched data circuits on adjacent pairs or channels. In addition, a significant proportion of the total impulse noise comes from the make and break contacts in electrical or communications switching and signaling equipment, much of which can be eliminated by careful maintenance. From this last statement, you can see just how important your everyday maintenance really is. With the addition of data transmission and all the different types of interface equipment being installed, our job is becoming more and more important.

Crosstalk. "Crosstalk" is the interference which results when two or more telephone talking circuits exist side by side, and the conversation on one circuit may be heard on the other. Obviously, this is objectionable. It not only may reduce intelligibility, but it may destroy secrecy. Being telephone men, you have probably had many different experiences with crosstalk and realize that there are many different causes of it. Here we are going to discuss only a few main causes of crosstalk.

Current in one line may be transferred to another line if the insulation between lines is faulty or if branches of trees or brush come in contact with the wires. This is a problem of proper maintenance, and crosstalk from this cause can be eliminated by keeping the lines in good mechanical condition.

One of the basic principles of electricity is that a magnetic field exists around a wire through which current is flowing. The magnetic field consists of concentric circular lines of force at right angles to the wire in space. The strength of the magnetic field varies inversely with the distance from the wire; that is, the greater the distance, the weaker the magnetic field. The magnetic field has the same waveform as the current that produces it. If the current is constant in magnitude and direction, the magnetic field is constant in strength and direction. If the current is alternating, as it is in the case of voice frequencies, the magnetic field varies instantaneously in magnitude and changes direction every half cycle. If such a varying magnetic field cuts an adjacent conductor, it induces an alternating EMF in the conductor in accordance with the generator principle. The magnitude of this EMF varies inversely with the distance between the center of the magnetic field and the conductor. The conductor is said to be inductively coupled to the original wire which produces the magnetic field.

"Capacitive coupling" is an association of two or more circuits with one another by means of capacitance mutual to the circuits. It is also called electrostatic coupling. Capacitive coupling produces an unbalanced EMF in a circuit because of the capacities between the wires of an adjacent circuit and ground and the associated electric fields. When there is a conversation on each circuit, the current flowing aplifies the other conversation that was allowed to pass over because of the action of the capacitance coupling.

Other noise. Other types of noise in telephone cables are:

(1) Noise to ground—this is a result of capacitive or inductive unbalance to ground existing between the two conductors of the circuit pair. There is always some noise to ground, even in a balanced pair. But if one conductor has a higher noise level or potential to ground than the other, the differential voltage appears as circuit noise between the two conductors.

(2) Metallic noise—this may be produced by a variety of sources, including galvanic (battery) action caused by a combination of moisture and mineral salts in damp cable and poor splice continuity.

(3) Longitudinal noise—this is induced along a cable conductor. If an unbalanced condition exists in a cable pair, a nearby induction field will produce a differential voltage between the two unbalanced conductors.

Reduction of Noise. As we have already indicated, noise can result in a cable pair from a variety of sources. Any electronic noise of whatever type, appearing on a circuit in competition with a signal, represents degradation of that signal. It is, therefore, of prime importance to avoid the occurrence of noise as far as possible. There are a number of preventive actions which will aid you in meeting this objective.

Selective assignment of pairs. Telephone cable transmission systems are always subject to noise injection from outside sources as well as high-level sources from within the cable itself (adjacent pairs). The fact that cable is shielded does not prevent noisy low-level circuits in the cable. Nonshielded cross connections of considerable length exist in every telephone central office, and cross connected pairs from various cables lie in a common bundle on the frames. This proximity both of high- and low-level circuits in a high-level noise environment (the central office) caused by switching equipment, etc., introduces white and impulse noise to low-level circuits, often to an unacceptable degree. Within the cable, the physical placement (pair numerical assignment) of various types of circuits is a very common cause of an unacceptable high noise level. Selective assignment of cable pairs according to use can be instrumental in reducing both white and impulse noise levels in critical circuits. For instance, the assignment of regular telephone pairs, high-level audio and teletype circuits and low-level digital circuits in an exchange cable is usually dependent on random choice, modified by some routing requirements. However, it is often possible to place all high-level assignments in pairs physically adjacent to the cable sheath; then, with the regular telephone circuits assigned to the next higher numbered bundle, the low-level critical circuits may be placed in the center of the cable. As a result, the telephone pairs act as a partial shield separating the high and low level assignments. This type of selective reassignment has actually reduced the general noise level in critical low level circuits by as much as 20 dB in some cables.

Shielded cross connects. The use of shielded pair cross connections (jumpers) is effective in noise reduction. They can be used on both high- and low-level circuits, and should be used at least on low-level circuits where the total cross connection length exceeds 3 feet.

Grounding. Proper grounding at appropriate points is important in achieving a low noise level in cable circuits. In unbalanced circuits, ground loops may result when the circuit is grounded at both ends and the grounds turn out to be at unequal potentials. This situation causes the circuit to be very susceptible to interference. The objective of grounding is to provide a path to earth of as low a resistance as possible. It is, therefore, imperative to provide a well-bonded, low impedance ground plane. Where there are two separate grounds in a building, the choice of which to use in a particular case can be difficult. In general, ground effectiveness tests should be performed on both grounds, and the lower resistance ground should be used. However, this is not infallible and, if lower overall system noise and signal distortion can be achieved, the poorer ground should be used.

Capacity balance. Cables, since they often contain hundreds of pairs of wires, are particularly susceptible to crosstalk caused by capacitive coupling between adjacent pairs. An important reason for this is the fact that the various wires exhibit different capacities to ground, making the system unbalanced to ground. One method of overcoming this is to equalize the capacities by transposing the various wires in the cable at points where one length of cable is spliced to an adjacent length of cable. Another method consists of equalizing the capacities by adding capacity to those pairs of wires that show less capacity to ground than do other pairs. This capacity is added by connecting the wires on one end of a short length of twisted pair to the cable pair and leaving the wires on the other end of the short length unconnected.

Filters. Battery chargers and similar apparatus used to maintain batteries in common battery systems are often the cause of hum, because the output voltage from these devices contains large amounts of energy at random frequencies. Filtering the output voltage by means of low-pass filters which consist of series choke coils and shunt electrolytic condensers of fairly large capacity, removes the higher frequencies that lie in the voice-frequency range and, therefore, prevents noise interference from this source.

Pressurization. The conductors in the telephone outside cable plant are protected from moisture damage by a normally waterproof covering. Sheath damage does occur due to a number of causes and presence of water can result, leading to signal losses and the introduction of noise. Internal pressurization of cable by compressed air is a technique used to protect the cable plant from damage due to breaks in the cable sheath. Any sudden deviation from the normal amount of air required to maintain that pressure, or any sudden drop in measured pressure in one particular area will indicate a sheath rupture which might normally go undetected. In addition, loss of air under pressure through small breaks in the cable sheath will tend to prevent the entry of any moisture. Maintenance of cable pressure and early attention to any loss of pressure will pay substantial dividends in cable performance and avoidance of noise. I'm sure all of you are familiar with the PMI of the cable pressurizer. If the preventive measures are not completely successful and a circuit is still subject to excessive noise, a thorough analysis of circuit conditions must be made, and due consideration given to the recorded measurements.

Exercises (827):

1. What type of noise results if harmonic energy is coupled into a cable?

2. Make and break contacts in electrical or communications switching equipment can cause what type of noise?

3. What type of noise results from electrostatic coupling of two circuits?

4. If differential voltage appears between two conductors, what type of noise results?

5. What type of line noise can be overcome by using capacitive balance?

6. What type of noise is reduced by selective pair assignment?

7. How can noise coupled into shielded cable within the central office be reduced?

828. Using figures 4-12 through 4-14 as necessary, differentiate among the types of distortion that occur on telephone transmission lines, identifying each type in the situation given.

Desired Transmission Characteristics. As a wave travels along a transmission line, its amplitude is attenuated and its phase is shifted. For the wave to be transmitted without distortion, it is necessary that each component wave be attenuated in the same proportion, and that the phases of the component waves be shifted by amounts directly proportional to their frequencies, no matter what the frequency components may be. Figure 4-12 illustrates undistorted transmission of a complete wave. The solid line represents the input and output waves. This complex wave can be considered as made up of a 500-cycle sine wave with an amplitude of 10 volts (dotted line) and a 1,500-cycle sine wave with an amplitude of 8 volts. B, on figure 4-12, represents the same wave after it has passed through a transmission line that has an attenuation ratio assumed to be 2 to 1. As a result, the 500-cycle wave (dotted line) now has an amplitude of 5 volts as compared with the 10 volts it had at transmission. The 1,500-cycle wave (dot-and-dash line) is attenuated from 8 volts to 4 volts, which is a ratio of 2 to 1. The amplitude of the output wave (solid line) has been attenuated; but note that its shape remains the same; that is, the wave is undistorted. The reason for this is that both sine waves were attenuated the same amount.

Note also that the 500-cycle wave, in B, has had its phase shifted by 30°. The 1,500-cycle wave must have its phase shifted by 90° in order that the phase shifts have the same proportions as the frequencies. The phase of the output wave (solid line) necessarily has been shifted also, but the shape of the wave remains the same as in A; it has not been distorted by the phase shifts.

Frequency Distortion. On actual transmission lines, not all waves are attenuated the same amount; the attenuation increases as the frequency of the transmitted wave increases. This results from the effects of capacitance, leakage, inductance, and resistance of the line. The effect of the variation in attenuation for different frequencies is shown in figure 4-13. The input wave, in A, is the same as that shown in figure 4-12. After moving along the line some specific distance (as seen in B, fig. 4-13) the 500-cycle component (dotted line) has an amplitude of 5 volts or an attenuation of 2:1. However, the 1,500-cycle component (dot-and-dash line) now has an amplitude of only 2 volts, an attenuation of 4:1, because of the poor frequency response of the line. Thus, the output wave has been attenuated much as in the undistorted case. Note, however, that the shape of the transmitted wave has been changed, or distorted, due to differing relative attention of the high-frequency and low-frequency components of the input wave.

Phase Distortion. This type of distortion is not too harmful for voice transmission, since the ear is relatively insensitive to phase delay; however, it constitutes the most serious impairment to data transmission, particularly over telephone voice channels. The main sources of phase distortion are loaded cables and carrier channel filters. It is also caused by the unavoidable capacitive and inductive reactances present in most communications channels and by echoes from imperfect line terminations or impedance mismatches between line sections or between the line and office apparatus.

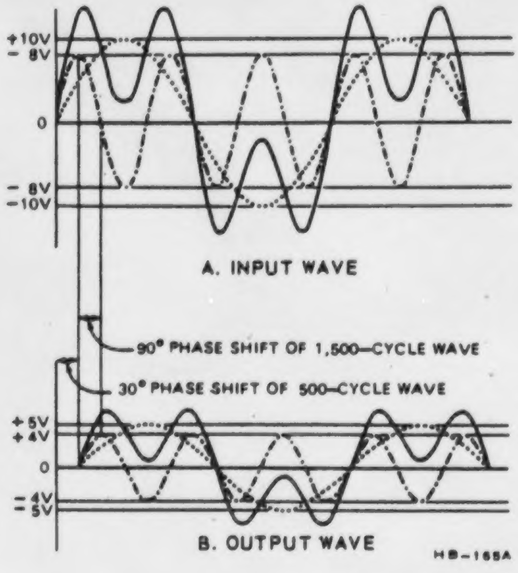


Figure 4-12. Desirable transmission conditions.

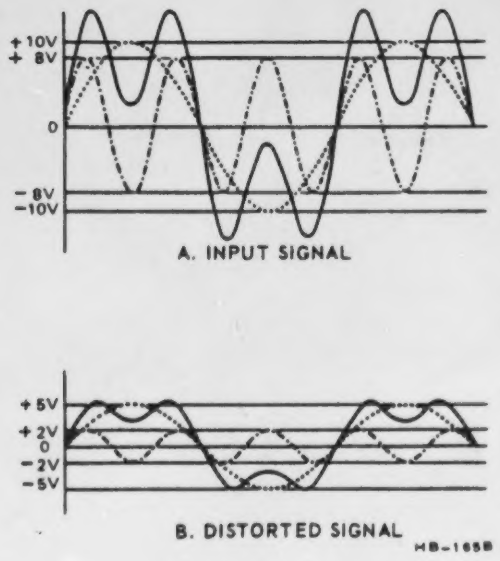


Figure 4-13. Frequency distortion.

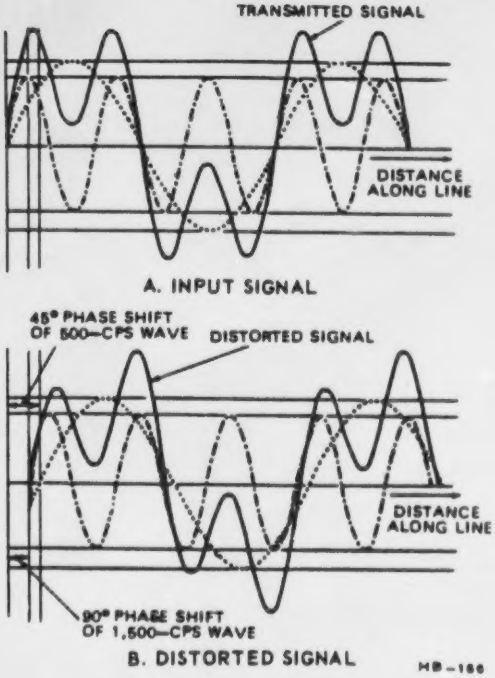


Figure 4-14. Phase distortion.

The effect of the variation of the phase shift is illustrated in figure 4-14. Again, the input wave shown in A is identical with that seen in figure 4-12,A. In figure 4-14,B, the 500-cycle component (dotted line) has been delayed (phase shifted) 45°. For the output signal to be undistorted, the high-frequency component must be delayed 135°, thus, maintaining the same phase relation between the 500-cycle and 1,500-cycle components. However, on an actual line the 1,500-cycle component is not delayed as much *in proportion* as the 500-cycle component. Figure 4-14,B, shows the effect of only 90° delay for the 1,500-cycle component. Notice that the shape of the output wave is changed as a result of phase distortion caused by the line. Phase distortion and frequency distortion occur together, because the same physical constants of the line (series resistance, series inductance, and shunt capacitance) that produce one also cause the other.

Unbalance. In transmission systems, balance (or unbalance) at the input and output of the audio circuit is important. The balance to ground, in the case of input circuits, determines the amount by which currents fed into the system from external circuits are suppressed. With output circuits, it determines the degree to which currents are generated and passed on. Do not confuse the words "mismatched" and "unbalanced." An unbalanced line may very well be matched in the sense that it is terminated correctly in its characteristic impedance.

Circuit unbalance is related to lines, voltage sources, and loads. An unbalanced transmission line, load, or source is one where one conductor or

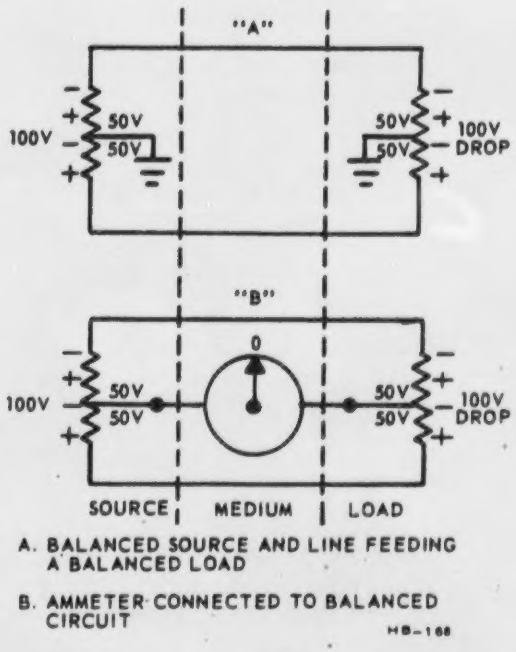

"A"
100V
50V
50V
50V
50V
100V DROP
"B"
0
100V
50V
50V
50V
50V
100V DROP
SOURCE
MEDIUM
LOAD
A. BALANCED SOURCE AND LINE FEEDING A BALANCED LOAD
B. AMMETER CONNECTED TO BALANCED CIRCUIT
HB-168

Figure 4-15. Balanced source and line feeding a balanced load.

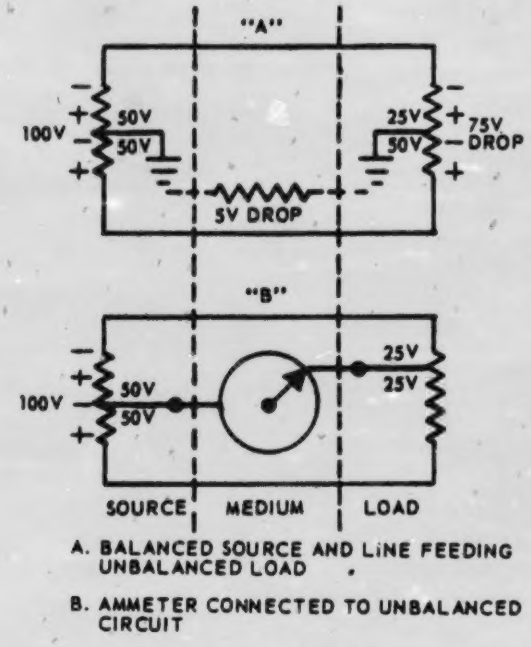

"A"
100V
50V
50V
25V
50V
75V
DROP
5V DROP
"B"
100V
50V
50V
25V
25V
SOURCE
MEDIUM
LOAD
A. BALANCED SOURCE AND LINE FEEDING UNBALANCED LOAD
B. AMMETER CONNECTED TO UNBALANCED CIRCUIT

Figure 4–16. Balanced source and line feeding an unbalanced load.

terminal is at ground potential, while the other is at some value above or below ground. In other words, the voltages measured from the two conductors or terminals are not equal.

Figure 4-15,A, shows a balanced source and line feeding a balanced load, with the center tap of both the source and the load connected to ground. By removing the grounds from both the source and the load and connecting an ammeter in the circuit, as shown in figure 4-15,B, you have an equivalent circuit. There is no potential difference between the load and the source where the ammeter is connected into the circuit. In this example, the ammeter would indicate no current flow through the reference ground. If this is the case, then all the power is delivered to the load (maximum transfer).

Figure 4-16,A, shows a balanced source and line feeding an unbalanced load, with the center tap of both the source and the load connected to ground. Again, by removing the grounds from both the source and the load and connecting an ammeter into the circuit, as shown in figure 4-16,B, you have an equivalent circuit. You can see that there is now a potential difference between the load and the source where the ammeter is connected. Current is shown flowing through the ammeter because, in this unbalanced circuit, you would have current flowing to your reference ground. This ground is a resistance, and some voltage will be dropped across it. As a result, less power will be delivered to the load. If correct levels cannot be established at a system interface, unbalance could be a possible cause.

Exercises (828):

1. If the output signal from a transmission line resembles the input signal in every way except its amplitude, what type of distortion has occurred?

2. A line which attenuates a 1,500-Hz signal more than a 500 Hz produces, what type of distortion?

3. If a complex wave is applied to a telephone line which delays its 2,500-Hz component 30° and delays its 500-Hz component 6°, what type of distortion is present in the output signal?

4. What type(s) of distortion will result if the insulation resistance of the dielectric of the line decreases?

5. How is the power delivered to the far end affected by an unbalanced circuit?

CHAPTER 5

Base Wire System Testing

A DETERIORATION in the transmission characteristics of a cable will show itself either as degradation or disruption of some or all of the communication circuits being transmitted through that cable. One of the most important methods of insuring that any deterioration is identified—and corrected—before it begins to interfere with the service being provided to the customer is the regular accomplishemnt of basic performance tests throughout the cable plant. This chapter covers these performance tests, test equipment required, procedure for making the tests, and analyzing the result.

5-1. Performance Test Equipment

The performance factors that may be checked to determine cable plant condition are loop and insulation resistance, noise, frequency response, and ground resistance. In this section we discuss the performance tests and equipment required for each.

829. Using figures 5-1 through 5-5 as necessary, isolate these tests used to check performance of the base wire system and the equipment used for each.

Loop and Insulation Resistance Test. The purpose of this test is to measure the DC resistance and insulation resistance of selected cable pairs.

The test equipment required for the DC loop resistance test is the AN/PSM-6A multimeter. You should be familiar with this piece of equipment from coverage in the tech school.

An AN/PSM-2A is used to perform the insulation resistance test. The set consists principally of a handcranked AC generator; a terminal board assembly containing rectifier, resistors, capacitor, neon glow lamps, and a meter.

These major component parts are housed in a die-case aluminum alloy case, shown in figure 5-1. On the outside of the case is a crank, two indicator buttons, two binding posts, the meter face, and a meter adjustment screw cover. Turning the crank in either direction until the indicator buttons glow steadily RED, generates 500-volts DC testing voltage which is available at the binding posts. When testing insulation, the meter pointer will indicate the resistance in megohms, hence the term "megger" is often used for this test set.

Impulse Noise Test. This test measures the amount of impulse noise present on the cable pair being tested. Impulse noise is the result of discrete disturbances of relatively high amplitude and short duration. Since it does not occur at regular intervals, the cable must be monitored over a period of time, using the Noise Test Set, Model 480A-1, seen in figure 5-2.

This test set operates on either 100 volts AC or battery power, in either the Monitor or Record mode. In Record an adjustable timer allows unattended accumulation of readings for up to an hour. Noise pulses up to 10 per second are counted on 3 levels and indicated by digital counters.

Notice, in figure 5-2, that 4 toggle switches allow the reference level for measurements to be set in steps of 10 dBrn. An 11-position switch below each digital counter is used to set the sensitivity of that counter in 2 dB steps. The total sensitivity for a counter is the sum of the reference level (10 dB toggle attenuator) and the sensitivity of the 2 dB step attenuator of that counter.

When each channel sensitivity is properly set, all impulses that have an amplitude equal to or greater than LO but less than MID will be recorded on the LO channel counter. All impulses that have an amplitude equal to or greater than MID but less than HI will be recorded on the MID channel counter. All impulses that have an amplitude equal to or greater than HI will be recorded on the HI channel counter.

Example:

Switch(s)	*Setting*
REF LEVEL	50 dBrn
LO LEVEL	0 dBrn
MID LEVEL	10 dBrn
HI LEVEL	20 dBrn

LO has a count of: 305
MID has a count of: 102
HI has a count of: 24

This indicates that 305 impulses had an amplitude that equaled or exceeded 50 dBrn but were less than 60 dBrn; 102 impulses had an amplitude that equaled or exceeded 60 dBrn but less than 70 dBrn; and 24

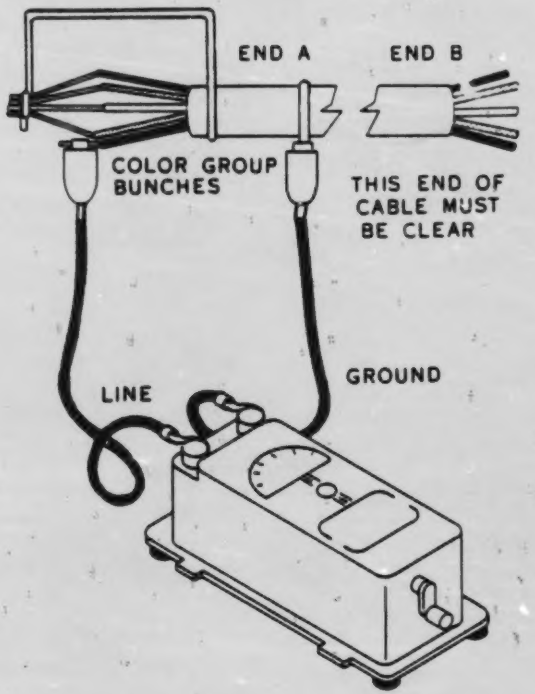


Figure 5-1. AN/PSM-2A, Megger.

impulses had an amplitude that equaled to or exceeded 70 dBrn.

We should mention that "dBrn" stands for "decibels above reference noise." Reference noise starts at -90 dBm; that is 0 dBrn is at -90 dBm. Thus 50 dBrn is equivalent to 40 dBm and 90 dBrn is equivalent to 0 dBm.

Idle Channel Noise Test. The purpose of this test is to measure the amount of electrical noise present on the specimen cable pair. Idle channel noise is the lower steady noise on the line excluding impulse noise.

The test measurement is done by using Model 3555B Transmission and Noise Measuring Set, shown in figure 5-3. This set provides a choice of 900 or 600 ohms impedance bridging or terminated for voice frequencies and 600, 135, or 75 ohm impedance bridging or terminated for carrier frequencies. A hold function permits seizing the line while measurements are being made at voice and program frequencies. The set is portable and can operate from either its internal battery, office battery, or 110 volts AC. Its noise measurement range is +10 dBrn to +121 dBrn with weighting filters 3 kHz flat, 15 kHz flat, C message, and program.

Frequency Response Test. The purpose of this test is to measure attenuation versus frequency for the selected pairs over a frequency range of 200 Hz to 5 kHz.

Equipment needed to accomplish this test is the Transmission and Noise Measuring Set, Model HP3555B, and a Telephone Test Oscillator, Model 236A. The test oscillator is used to send signals at selected frequencies over a cable pair to the transmission test set at the far end which measures the received signal strength. The Transmission and Noise Measuring Set has been covered previously, so we will not discuss it further here.

The test oscillator, seen in figure 5-4, generates a stable sine wave output at frequencies from 50 Hz to 560 kHz with an output amplitude of +10 dBm to −31 dBm. (The frequency of the output is controlled by the position of the frequency dial, multiplied by the setting of *Freq Range* switch.) The output is available from the front panel with standard binding posts and telephone jacks. The oscillator is portable and may be

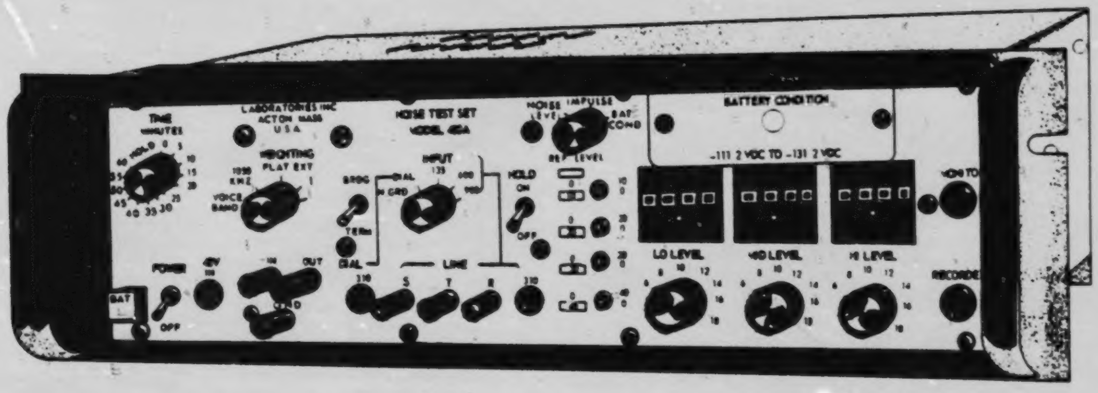


Figure 5-2. Noise Test Set, 480A-1.

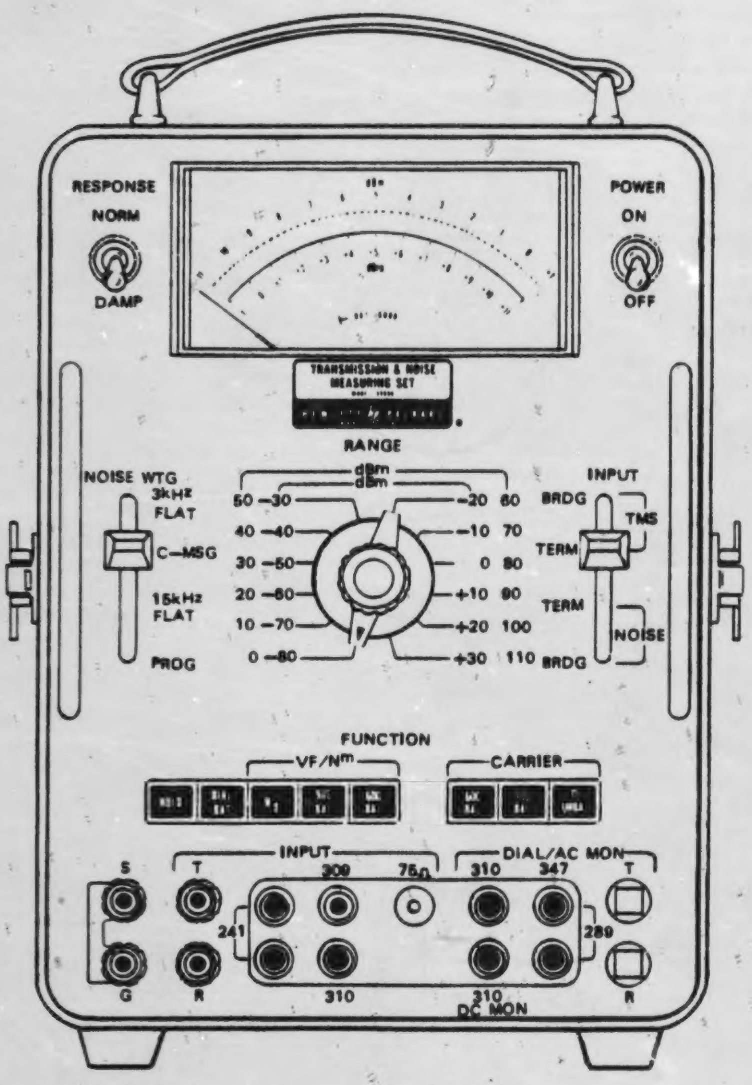


Figure 5-3. Transmission and Noise Measuring Set, Model 3555B.

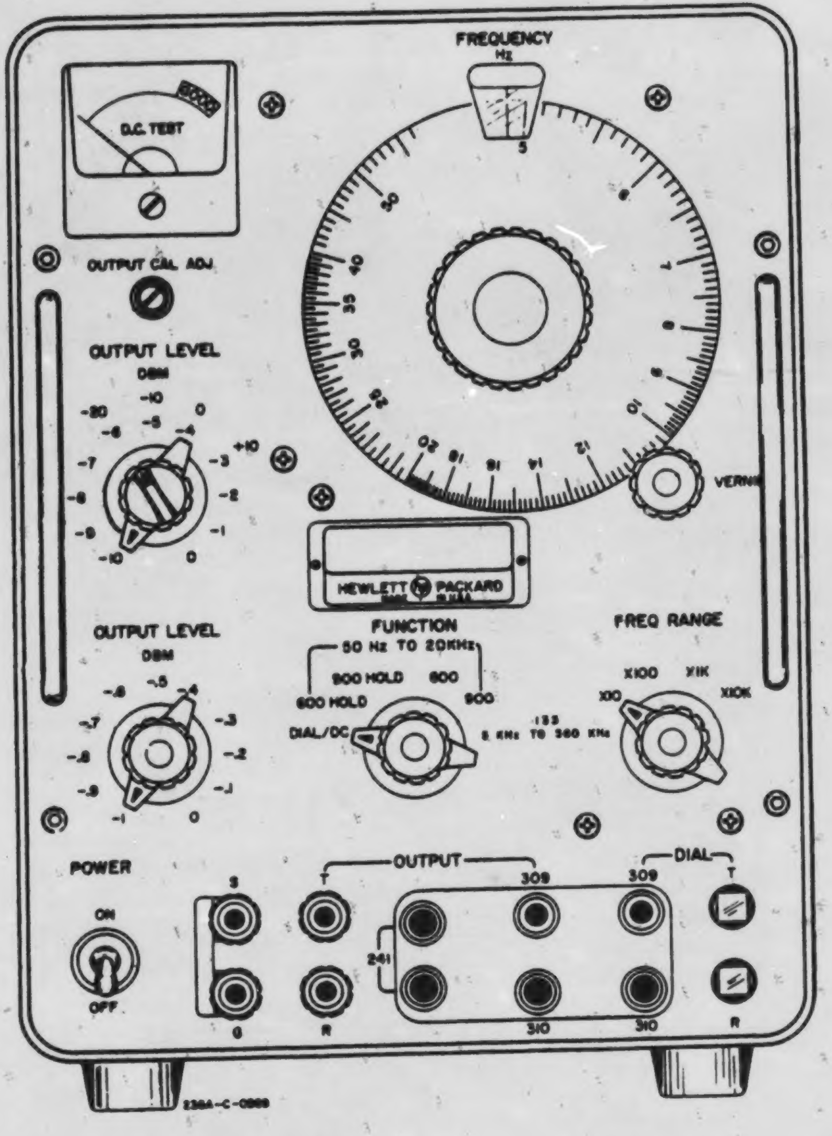


Figure 5–4. Telephone Test Oscillator, HP236A.

operated from either 110 volts AC or internal battery power. Provisions are made for talking and dialing with hook switch control.

Station Ground Resistance Test. This test is to measure the resistance of station and distant terminal grounds. It is made by using the Vibroground Earth Resistance Test Set, which figure 5-5 shows. The ground resistance measurement made with this tester are direct readings and require no calculations. It is housed in a welded steel case with a carrying handle and removable cover. Its synchronous vibrator power supply operates on self-contained batteries.

Exercise (829):

1. What test equipment is used to perform the insulation resistance test?
2. Which test is used to measure the amount of electrical noise present on the selected cable pair?
3. The Vibroground test set is used for which test?
4. Which test is made using the Model 480A Noise Test Set?
5. What test is used to measure signal attenuation versus frequency over a range of 200 Hz to 5 kHz?
6. The AN/PSM-6A is used for which test?

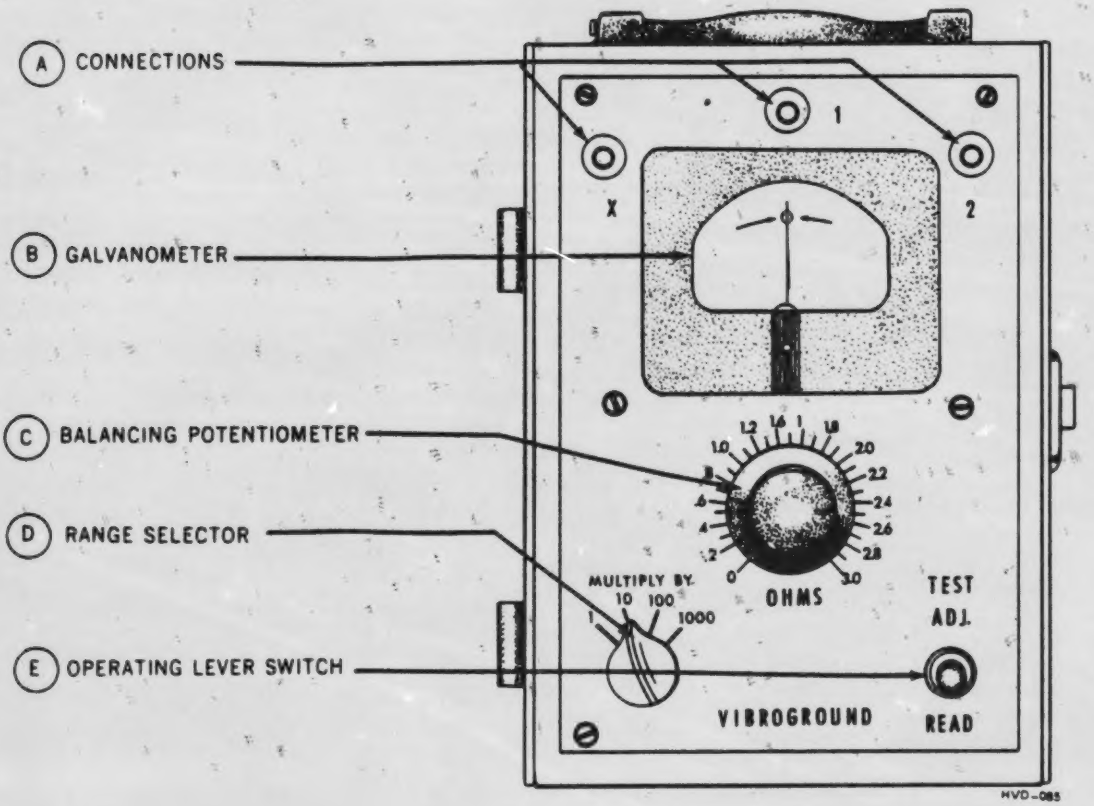


Figure 5-5. Vibroground Earth Resistance Test Set.

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7. What test equipment is required to perform the frequency response test?

5-2. Making and Recording Performance Tests

830. Using figures 5-6 through 5-10 as required, give the information that must be taken from AFTO Forms 224 and 376 and the cable map to initiate AFTO Forms 484, 485, and 494.

> NOTE: AFTO Forms 484, 485, and 494, referred to throughout BOF 830 and the remainder of this chapter, are obsolete and no longer in official use. But specialists in this field must know not only the information found on these forms but also exhibit the ability to complete such forms accurately. So although they are *not* official,
>
> AFTO Forms 484, 485, and 494 are included here for practice in the use of appropriate forms. New, similar forms are in the process of being prepared and are to be substituted for these as soon as they become officially available.

AFTO Form 484. Figure 5-6 illustrates this form, which is used to record the results of the DC loop resistance and insulation resistance test. One form is used for each cable pair tested. Data for the heading blocks is found as follows: Base is where test is being conducted. Cable No. and Pair No. are taken from either AFTO Form 224, seen in figure 5-7, or AFTO Form 376, shown in figure 5-8. From (Building No.) is where you are while making the test, and To (Building No.) is where the other end of the cable under test terminates. Data for the third heading line is obtained from the base cable maps which you studied in Chapter 4. The second blocks for Gauge and Kft are used if different gauge cable is spliced into the run being tested. The rest of the entries are made during the DC loop and insulation resistance tests.

AFTO Form 485. Figure 5-9 shows how this form is used to record the result of frequency response, idle channel noise, and impulse noise tests. One form is used for each cable pair tested. The heading information for this form is obtained from the same sources as that of AFTO Form 484. The remaining entries are made during the frequency response, idle channel noise, and impulse noise tests.

AFTO Form 494. This form, shown in figure 5-10, is used for recording the results of the station ground resistance test. Base and Cable No. are taken from AFTO Form 224, and the Building "From" and "To" entries are as previously described for AFTO Form 484. The remaining information is obtained during the station ground resistance test.

Exercises (830):

1. Where would you look to find the length of a cable pair?

2. If you checked 4 cable pairs, how many AFTO Forms 484 would you fill out?

3. What tests are recorded on AFTO Form 485, Audio Test Record?

4. What information is obtained from AFTO Form 224 for initiating AFTO Forms 484, 485, and 494?

5. When do you fill out both sets of gauge and length (Kft) blocks on AFTO Form 484?

831. Using figures 5-11 through 5-16 as needed, provide the required selected steps in the procedures for setting up and making cable performance tests.

Loop and Insulation Resistance Test. DC loop resistance is measured by connecting an AN/PSM-6A across a cable pair. The pair should be clear and not connected at any other terminal. Connect the test equipment as figure 5-11 shows. Set the AN/PSM-6A to read resistance, record the readings taken for the cable pairs on the AFTO Form 484.

Insulation resistance is checked by using a PSM-2A (megger). Certain safety factors should be observed before operating the megger. Thus:

- When checking insulation resistance with a megger, the conductors become charged and must afterwards be discharged to prevent possible shock to you. Discharge the conductors under test as soon as the test on a pair is completed.
- The arc resulting at the time of discharge is sufficient to ignite explosive mixtures of gas.
- Discharge the conductors at the megger terminals by means of a short piece of insulated wire.
- Disconnect all lines under test from any equipment.
- Make sure the megger is in a level position.
- Keep the test set as far as possible from strong magnetic fields such as those produced by transformers or motors.

Once all the precautions have been checked and observed, proceed with the following:

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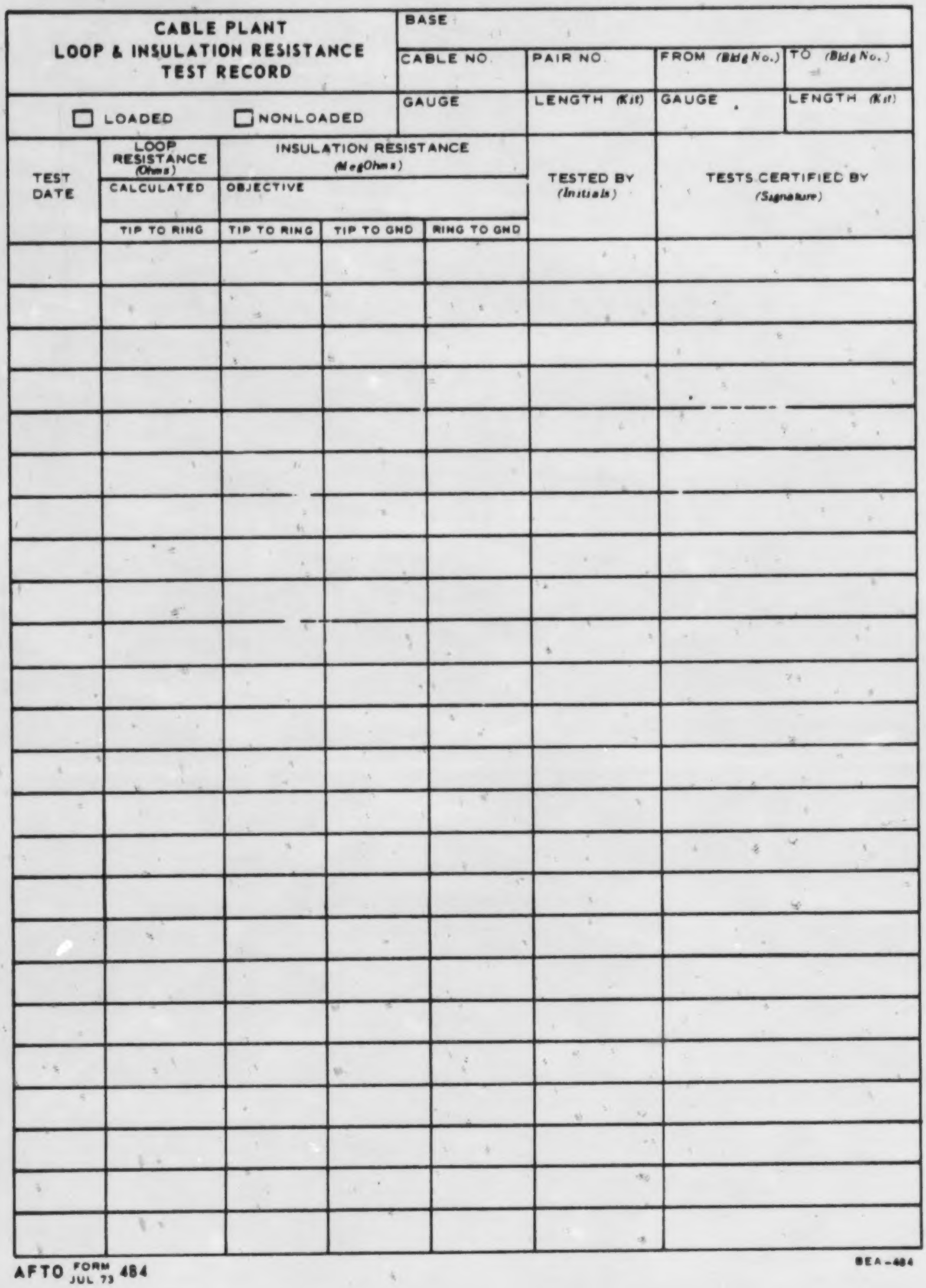


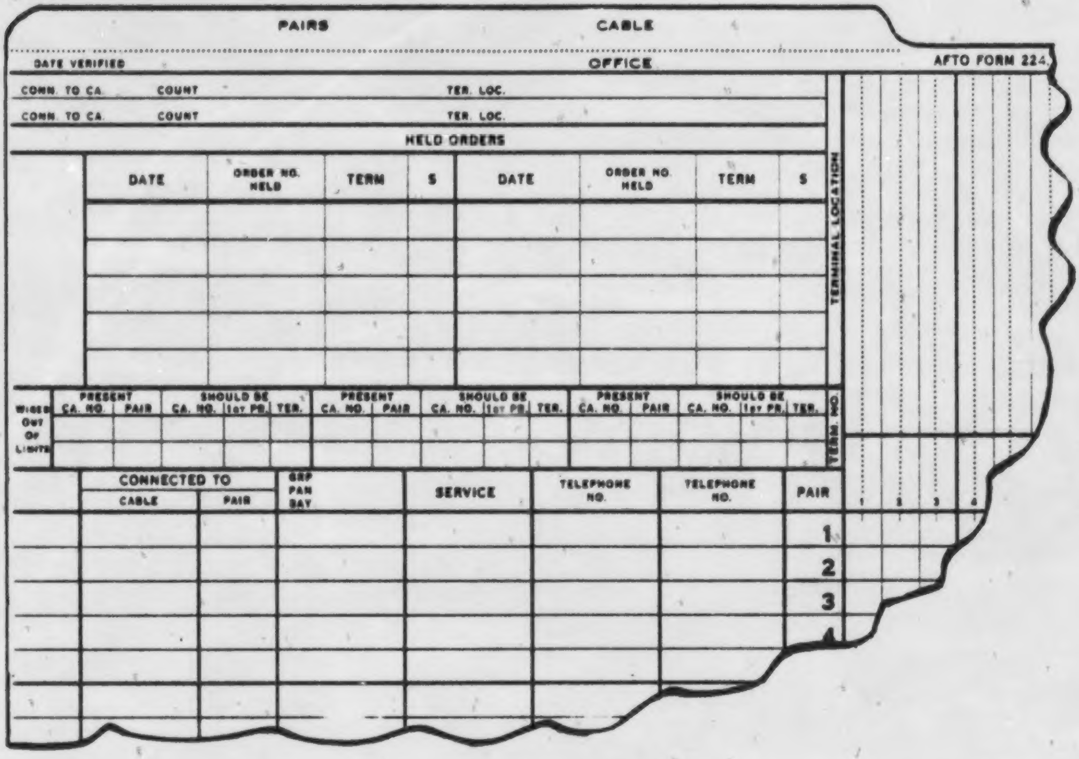
CABLE PLANT LOOP & INSULATION RESISTANCE TEST RECORD	BASE			
	CABLE NO.	PAIR NO.	FROM (Bldg No.)	TO (Bldg No.)
☐ LOADED ☐ NONLOADED	GAUGE	LENGTH (Kit)	GAUGE	LENGTH (Kit)

TEST DATE	LOOP RESISTANCE (Ohms)	INSULATION RESISTANCE (MegOhms)			TESTED BY (Initials)	TESTS CERTIFIED BY (Signature)
	CALCULATED	OBJECTIVE				
	TIP TO RING	TIP TO RING	TIP TO GND	RING TO GND		

AFTO FORM JUL 73 484

BEA-484

Figure 5-6. AFTO Form 484.



PAIRS CABLE

DATE VERIFIED OFFICE AFTO FORM 224.

CONN. TO CA. COUNT TER. LOC.

CONN. TO CA. COUNT TER. LOC.

HELD ORDERS

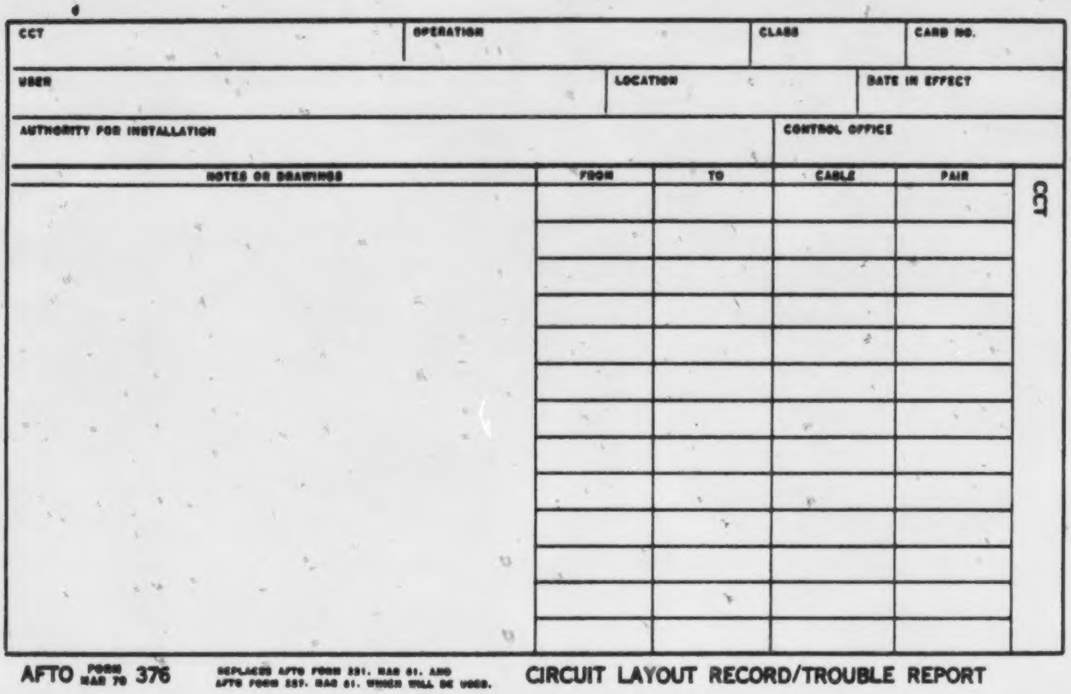
	DATE	ORDER NO. HELD	TERM	S	DATE	ORDER NO. HELD	TERM	S

TERMINAL LOCATION

WIRED OUT OF LIMITS	PRESENT		SHOULD BE			PRESENT		SHOULD BE			PRESENT		SHOULD BE			TERM. NO.
	CA. NO.	PAIR	CA. NO.	1ST PR.	TER.	CA. NO.	PAIR	CA. NO.	1ST PR.	TER.	CA. NO.	PAIR	CA. NO.	1ST PR.	TER.	

	CONNECTED TO		GRP PAN BAY	SERVICE	TELEPHONE NO.	TELEPHONE NO.	PAIR	1	2	3	4
	CABLE	PAIR									
							1				
							2				
							3				
							4				

Figure 5-7. AFTO Form 224.

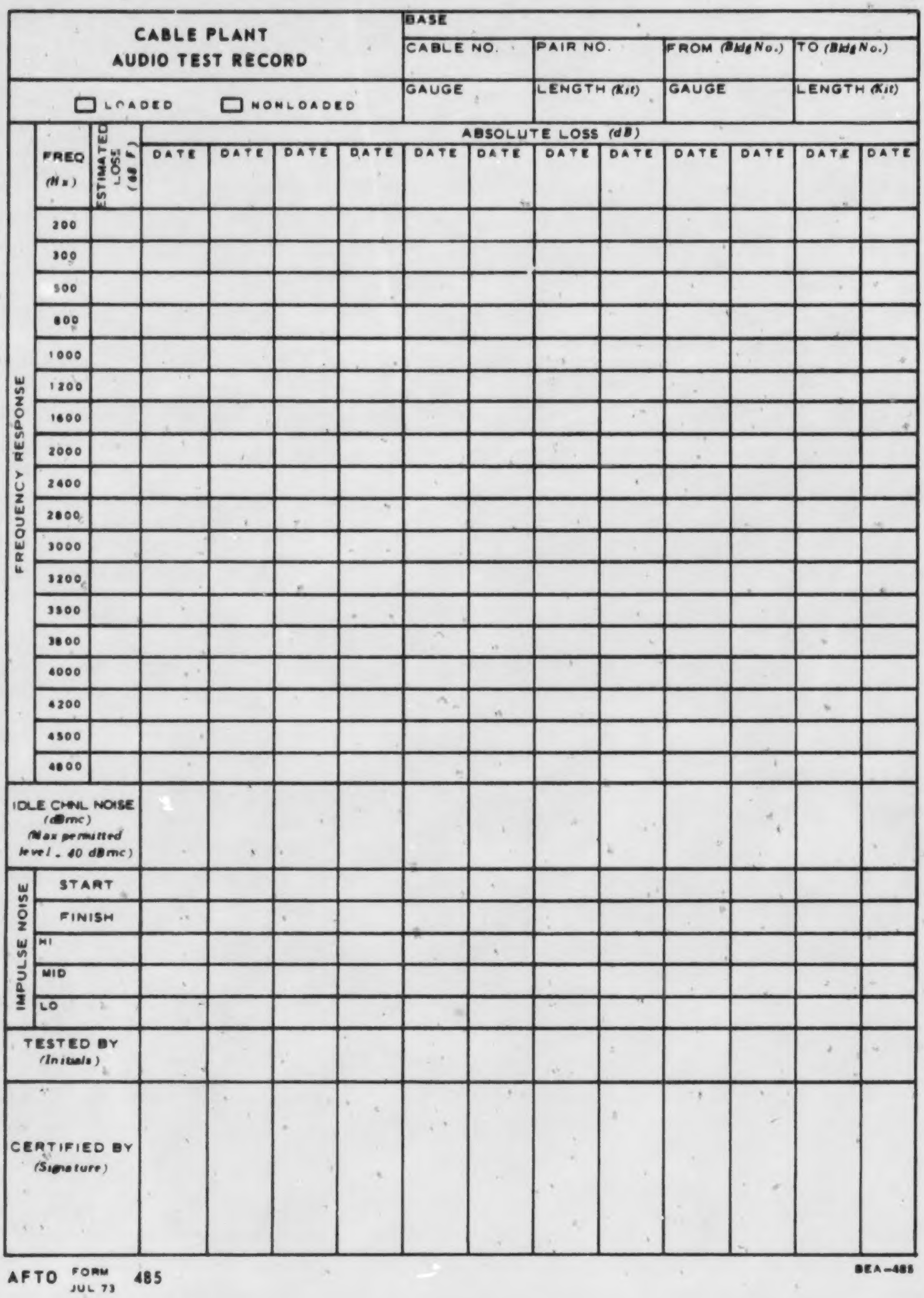


CCT	OPERATION	CLASS	CARD NO.
USER	LOCATION	DATE IN EFFECT	
AUTHORITY FOR INSTALLATION	CONTROL OFFICE		

NOTES OR DRAWINGS	FROM	TO	CABLE	PAIR	CCT

AFTO FORM MAR 70 376 REPLACES AFTO FORM 231, MAR 61, AND AFTO FORM 237, MAR 61, WHICH WILL BE USED. CIRCUIT LAYOUT RECORD/TROUBLE REPORT

Figure 5-8. AFTO Form 376.



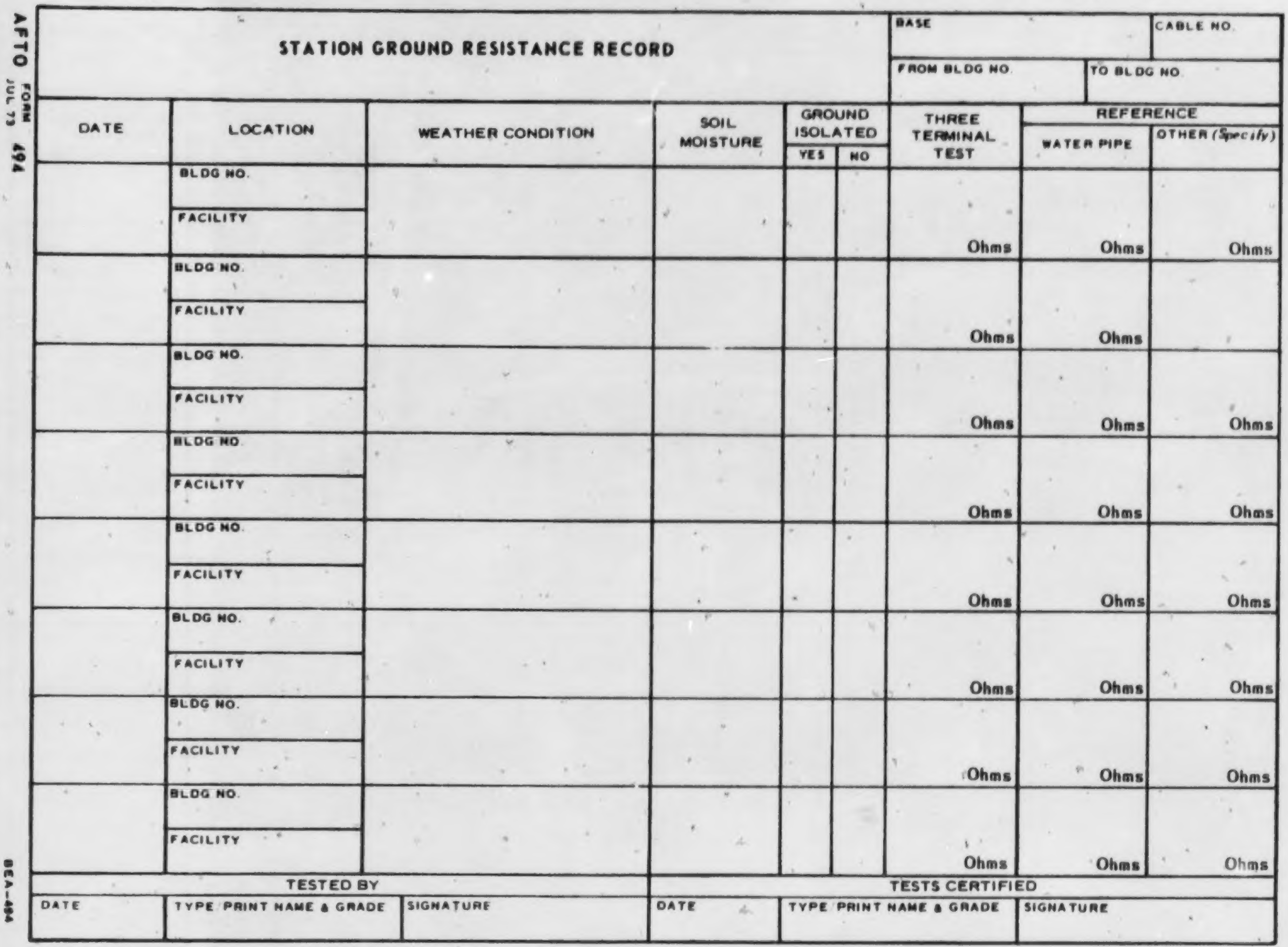
CABLE PLANT AUDIO TEST RECORD		BASE					
		CABLE NO.		PAIR NO.	FROM (Bldg No.)	TO (Bldg No.)	
☐ LOADED	☐ NONLOADED	GAUGE		LENGTH (Kft)	GAUGE	LENGTH (Kft)	

	FREQ (Hz)	ESTIMATED LOSS (dB F)	ABSOLUTE LOSS (dB)											
			DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE
FREQUENCY RESPONSE	200													
	300													
	500													
	800													
	1000													
	1200													
	1600													
	2000													
	2400													
	2800													
	3000													
	3200													
	3500													
	3800													
	4000													
	4200													
	4500													
	4800													
IDLE CHNL NOISE (dBrnc) (Max permitted level . 40 dBrnc)														
IMPULSE NOISE	START													
	FINISH													
	HI													
	MID													
	LO													
TESTED BY (Initials)														
CERTIFIED BY (Signature)														

AFTO FORM JUL 73 485

BEA—485

Figure 5-9. AFTO Form 485.



AFTO FORM JUL 73 494

STATION GROUND RESISTANCE RECORD	BASE	CABLE NO.
	FROM BLDG NO.	TO BLDG NO.

DATE	LOCATION	WEATHER CONDITION	SOIL MOISTURE	GROUND ISOLATED		THREE TERMINAL TEST	REFERENCE	
				YES	NO		WATER PIPE	OTHER (*Specify*)
	BLDG NO. FACILITY					Ohms	Ohms	Ohms
	BLDG NO. FACILITY					Ohms	Ohms	
	BLDG NO. FACILITY					Ohms	Ohms	Ohms
	BLDG NO. FACILITY					Ohms	Ohms	Ohms
	BLDG NO. FACILITY					Ohms	Ohms	Ohms
	BLDG NO. FACILITY					Ohms	Ohms	Ohms
	BLDG NO. FACILITY					Ohms	Ohms	Ohms
	BLDG NO. FACILITY					Ohms	Ohms	Ohms

TESTED BY			TESTS CERTIFIED		
DATE	TYPE PRINT NAME & GRADE	SIGNATURE	DATE	TYPE PRINT NAME & GRADE	SIGNATURE

BEA-494

Figure 5 10. AFTO Form 494.

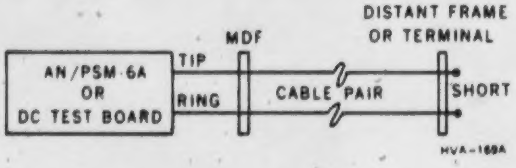


Figure 5-11. Setup for DC loop resistance test.

a. Check as follows to make sure that there is no leakage between the test leads of the megger:

(1) Connect two leads to the LINE and GROUND terminals of the megger. Leave the other ends disconnected. When the megger is operated, the scale should read "INFINITY."

(2) Now connect the two leads from the same terminals together and operate the megger. The scale reading should be "0."

b. Connect the LINE and GROUND leads to the cable pair to be tested as shown in the top part of figure 5-12.

c. Turn the crank of the megger until the indicator on the dial of the megger reaches a point where it remains fairly constant. If the insulation resistance is low, the needle usually reaches a steady position quickly and does not fluctuate. However, if the insulation resistance is high, it will usually take a little time for the needle of the indicator to reach a steady position on the dial.

d. Take the reading on the dial while the crank is still being turned.

e. Stop the crank and record the reading on AFTO Form 484.

f. Take a piece of well insulated wire and short it across the pair tested to discharge the pair as shown in the bottom of figure 5-12.

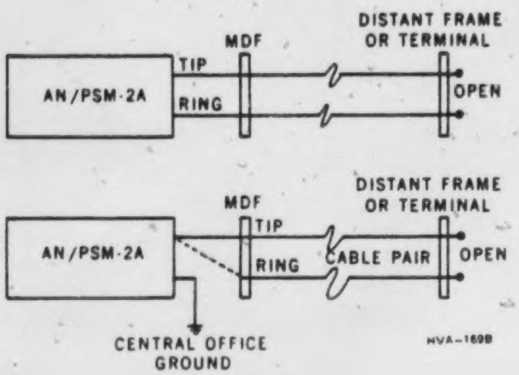


Figure 5-12. Setup for insulation resistance test.

Impulse Noise Test. The test equipment setup for the impulse noise test is shown in figure 5-13; use the 600-ohm resistor for nonloaded cable and the 900-ohm resistor for loaded cable.

Set up the 480A impulse noise counter as follows:

NOISE LEVEL/IMPULSE/BAT COND: IMPULSE position

Connect to cable pair using either line 310 jack or the T and R binding posts:

INPUT: 600 or 900 as appropriate.
BRDG/TERM: Term
WEIGHTING: Voice
HOLD: Off
REF LEVEL: 50 dBrn
COUNTERS: Low Level - 0 dBrn
Mid Level - 4 dBrn
Hi Level - 8 dBrn
Clear all counters
TIMER KNOB: Set to 15 minutes
POWER: On

Once the equipment is set up, adjust the reference level up or down until the setting is reached which will result in about 15 "HI" hits in 15 minutes.

Reset the counter to zero and the timer to 15 minutes for data or 30 minutes for voice.

Post the start time of the test to AFTO Form 485.

At the end of the test period, record the counter readings and the finish time on AFTO Form 485.

Idle Channel Noise Test. Test equipment is connected, as figure 5-14 reveals, with the 600- on 900-ohm resistor at the distant end for appropriate type cable.

Set the HP 3555B controls as follows:

FUNCTION: 600 Hold or 900 Hold as appropriate
INPUT: Terminate
POWER: ON
RANGE: 30 dBrn (blue setting)
WEIGHTING: 15 kHz Flat
RESPONSE: Normal

Now that the test equipment is set up, connect the HP 3555B to each pair under test, individually. If noise fluctuations appear on the meter, observe the pointer for a short while to establish the point at which the pointer appears most of the time, disregarding occasional high peaks. If fluctuations do not appear, adjust the Range switch until they do. Once this point is established, the idle channel noise level is the algebraic sum of the indication on the blue

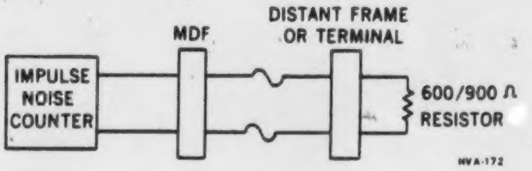


Figure 5-13. Setup for impulse noise test.

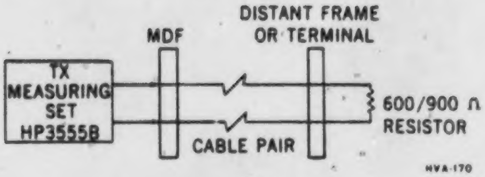


Figure 5-14. Setup for idle channel noise test.

dBrn meter scale and the dBrn Range switch setting. For example, if Range is set to 30 dBrn and the meter indicates +6 dBrn, the noise is 30 + 6 = 36 dBrn. Post the reading obtained to "Idle Channel Noise" section of AFTO Form 485.

Frequency Response Test. Connect a transmission and noise measuring set at the MDF and a test oscillator at the far end, as shown in figure 5-15.

Set the HP 236A test oscillator in the following configuration:

FUNCTION: 600 ohm or 900 ohm depending upon whether the cable is nonloaded or loaded
FREQUENCY RANGE: X100

At the MDF set the HP 3555B transmission measuring set in the following configuration:

FUNCTION: 600 ohm or 900 ohm as appropriate
NOISE WTG: 15 kHz Flat
RESPONSE: NORMAL
RANGE: to value calculated for the cable size, length, and temperature

Once the equipment is set up, turn both instruments "On" and determine the dB loss at each frequency listed, by sending the test signal at 0 dBm from the HP 236A and reading the loss on teh HP 3555B. Do not use frequencies above 3.5 kHz on H-88 loaded cables or 4.5 kHz on H-44 or D-66 loaded cables. The readings should be recorded on AFTO Form 485 in the frequency response section.

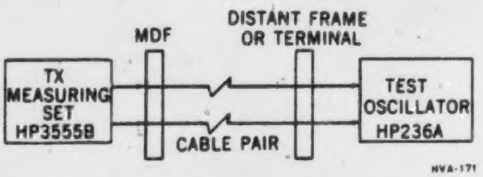


Figure 5-15. Setup for frequency response test.

Station Ground Resistance Test. Establish the proper distances that you will place the auxiliary current and auxiliary potential electrodes. These two distances are predetermined through the use of graphs appearing in TO 33A1-12-310-1.

Place the test set in a suitable location, near the grounding system to be tested.

Connect Vibroground terminal X to the grounding electrode or station ground, terminal 1 to the auxiliary potential electrode, and terminal 2 to the auxiliary current electrode.

Drive the auxiliary electrodes into the ground at the proper distances from the grounding system, in a straight line.

After the preliminary set up of the test equipment, displayed in figure 5-16, make the test as follows:

(1) If you have an idea of the general range of resistance to be measured, set Multiply By switch to a multiplying factor within this range. If unknown, select the highest multiplier range first.

(2) Operate the Test switch to the ADJ position. Rotate the OHMS control knob until the galvanometer indicates a balance at center scale. If the galvanometer reads to the right of center scale with the OHMS control at zero, set the Multiply By switch to the next lower range. If the galvanometer reads to the left of center scale with the OHMS control fully clockwise, set the Multiply By switch to the next higher range.

(3) After balance is achieved with the Test switch in the ADJ position, operate this switch to the READ position and rebalance the galvanometer with the OHMS control.

(4) Read the resistance on the calibrated OHMS scale. If this indication is less than 1/10 of full range, set the Multiply By switch to the adjacent lower range

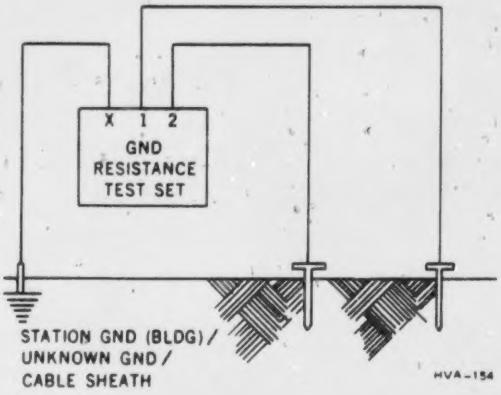


Figure 5-16. Setup for station ground resistance test.

and rebalance the galvanometer. (This provides better readability and resolution.)

(5) Multiply the OHMS scale indication by the factor indicated by the Multiply By switch. This product is the resistance of the grounding system connected to terminal X. Record this resistance value.

(6) If balance cannot be achieved under any conditions, check the test leads for opens. Make sure that the leads are properly connected. If the trouble persists, the grounding system may e inadequate due to a high resistance beyond the range of the Vibroground.

Exercises (831):

1. What source of power is used for the Megger, AN/PSM-2A?

2. What type of load is used at distant frame or terminal during a DC loop resistance test?

3. What must be done to a cable pair after completing an insulation resistance test?

4. What is the measurement time for the impulse noise test?

5. To what level is the reference level initially set for the impulse noise test?

6. When making an idle channel noise test, what value of load resistor is used for nonloaded cable?

7. When making an idle channel noise test, what do you do if noise fluctuations do not appear on HP 3555B?

8. During a frequency response test, what is placed at the distant frame or terminal?

9. To what is terminal X of Vibroground test set connected when checking station ground resistance?

10. To what level do you initially set the three counters on the 480A noise test set when measuring impulse noise?

11. When setting up for a frequency response test, what determines where the function switch on both pieces of test equipment should be set?

5-3. Interpretation of Test Results

832. Using tables 1 through 6 as necessary and given test results, determine which cable pairs meet specifications.

Loop and Insulation Resistance. To determine if the pair meets DC *loop resistance* specifications, compare the readings obtained during the test with the calculated value. The calculated value is obtained by multiplying the length of the cable pair times the value taken from table 5-1 for the proper gage and temperature. The readings should be within ±20 percent; if not, make the entry in red on AFTO Form 484.

To determine if the *insulation resistance* is within limits, compare the test results with the objective value. The objective value is obtained by multiplying the value from table 5-2 times the length of the cable pair. The pairs that fail to meet the criteria are entered in red on AFTO Form 484.

Impulse Noise. For a cable to meet the specification for voice, the impulse noise count is not to exceed 90 hits at 59 dBrnc in any 30-minute period; the maximum impulse noise count for a data circuit is 15 hits in 15 minutes at 59 dBrnc. Pairs that do not meet the criteria are annotated in red on the AFTO Form 485.

Idle Channel Noise. For normal purposes, the idle channel noise level present on a cable pair is not to exceed 40 dBrnc. Any other use of the cable pair will require special parameters related to the requirements of the specific circuit concerned. In other words, when a new circuit is installed and the design requires less noise, special installation procedures will be followed to obtain them. Idle channel noise, of course, applies to an existing circuit working on a system similar to "Microwave" where an idle line termination is necessary to prevent excessive noise on that channel of operation when it is not in use. Circuits with a normal "tone-on idle condition," such as 2,600 Hz used for SF unit signaling, are not affected by this

TABLE 5-1

CABLE DC RESISTANCE

Conductor Temp °F	19 ga		22 ga		24 ga		26 ga	
	Ohms/ K Ft	Ft/Ohm	Ohms/ K Ft	Ft/Ohm	Ohms/ K Ft	Ft/Ohm	Ohms/ K Ft	Ft/Ohm
-10	13.8	72.6	27.3	36.7	44.1			
- 5	13.9	72.0	27.9	35.8	44.4			
0	14.1	71.3	28.2	35.5	44.8	22.1	72.5	13.8
5	14.2	70.6	28.5	35.2	45.2			
10	14.3	69.9	28.8	34.8	45.7	21.7	74.0	13.5
15	14.5	69.3	29.0	34.5	46.2			
20	14.6	68.6	29.3	34.1	46.7	21.3	75.8	13.2
25	14.8	67.9	29.6	33.8	47.2			
30	14.9	67.2	29.9	33.5	47.7	20.8	77.0	13.0
35	15.1	66.6	30.2	33.1	48.1			
40	15.2	65.9	30.5	32.8	48.6	20.5	78.9	12.7
45	15.4	65.2	30.8	32.5	49.1			
50	15.5	64.5	31.2	32.1	49.5	20.0	80.6	12.4
55	15.7	63.8	31.5	31.8	50.1			
60	15.8	63.2	31.9	31.4	50.6	19.6	82.0	12.2
65	16.0	62.5	32.1	31.1	51.3			
68	16.1	62.05	32.4	30.9	51.9	19.3	83.4	12.0
70	16.2	61.8	32.5	30.8	52.0	19.2	84.2	11.9
75	16.4	61.1	32.9	30.4	52.3			
80	16.6	60.4	33.3	30.1	52.9	18.8	85.5	11.7
85	16.8	59.8	33.5	29.8	53.5			
90	16.9	59.1	34.1	29.4	54.1	18.3	87.9	11.4
95	17.1	58.5	34.4	29.1	54.7			
100	17.4	57.7	34.9	28.7	55.3			
105	17.6	57.0	35.2	28.4	56.2			
110	17.8	56.4	35.6	28.1	56.8			
115	17.9	55.7	36.1	27.7	57.5			
120	18.2	55.0	36.5	27.4	58.2			

TABLE 5-2
CABLE INSULATION RESISTANCE

	Required Insulation Resistance				Required Insulation Resistance	
Length of cable (ft)	Plastic Insulated (Mohms)	Paper Insulated (Mohms)		Length of cable (miles)	Plastic Insulated (Mohms)	Paper Insulated (Mohms)
500	7,920	5,280		1	750	500
1,000	3,960	2,640		2	375	250
1,500	2,640	1,760		3	250	167
2,000	1,980	1,320		4	170	125
3,000	1,320	880		5	150	100
4,000	990	660		6	125	88.3
5,000	792	528		7	107.1	71.3
6,000	660	440		8	93.3	62.5
7,000	566	377		9	83.8	55.5
8,000	495	330		10	75	50
9,000	440	293		11	68.1	45.4
10,000	396	264		12	62.5	41.7

condition. Voice transmissions are not normally affected by idle channel noise, but if a pair is to be used for data transmissions, the effect is important. All cables that fail to meet the criteria are entered in red in appropriate section of AFTO Form 485.

Frequency Response. Information recorded on the AFTO Form 485 must consider if loaded or nonloaded cable is being tested.

Nonloaded cable pairs should have losses within ±10 percent of calculated values, and these calculated values are obtained by using tables 5-3, 5-4, or 5-5 values times length of cable pair. The pairs that fail to meet this criteria cannot be used for data circuits, but they could possibly be used for voice circuits. To verify possible voice circuit usage refer to TO 31Z-10-15.

On loaded cable pairs random variations are considered acceptable if the measured facility loss compared to the calculated value is within ±10 percent at 1,000 Hz and 2,000 Hz and ±20 percent at 300, 500, and 3,000 Hz. If the 1,000 Hz loss varies more than ±10 percent from the calculated value, shown in table 5-6, it is still possible for the cable to have no major irregularities if the measured effective facility loss is within ±20 percent of the measured 1,000-Hz facility loss. The effective facility loss is figured by computing the average of the measured losses at 300, 500, 1,000, 2,000, and 3,000 Hz. This is illustrated as follows:

Frequency (Hz)	*Measured Loss dB*
300	7.4
500	9.1
1,000	9.7
2,000	10.3
3,000	11.0
Total Facility Loss	47.5

Effective facility loss = 47.5/5 = 9.5 dB which meets the requirement.

Any pairs that do not meet the criteria will be entered in red on AFTO Form 485.

Station Ground Resistance. The TO for Telephone Inside Plant Engineering, Central Office Building Design Criteria, specifies 5 ohms impedance to earth for telephone equipment station grounds. If your reading is higher than 5 ohms, insure that you have performed the test correctly and that you have obtained the correct information about the station ground you have tested. The ground system was designed around the soils ability to conduct; if the resistance is too high, there are only a few possible causes. Usually the station ground is rotting away because of rust and it must be replaced. The main thing to remember here is to be sure you have collected all available information about your particular station ground before making any decisions.

TABLE 5-3
NONLOADED CABLE ATTENUATION CHARACTERISTICS
(DECIBELS/KFT AT 38° F.)

Frequency (Hz)	19 GA	22 GA	24 GA	26 GA
200	.105	.149	.188	.238
300	.128	.183	.231	.292
500	.164	.235	.297	.376
800	.206	.296	.374	.474
1000	.228	.329	.418	.530
1200	.249	.360	.457	.580
1600	.283	.413	.525	.668
2000	.312	.458	.585	.744
2400	.338	.499	.638	.813
2800	.360	.535	.686	.876
3000	.370	.552	.709	.906
3200	.380	.568	.730	.934
3500	.394	.591	.761	.975
3800	.406	.613	.791	1.014
4000	.414	.627	.810	1.039
4200	.422	.640	.828	1.064
4500	.432	.660	.854	1.099
4800	.442	.678	.880	1.133

616

TABLE 5-4

NONLOADED CABLE ATTENUATION CHARACTERISTICS
(DECIBELS KFT AT 68° F.)

Frequency (Hz)	19 GA	22 GA	24 GA	26 GA
200	.109	.155	.195	.246
300	.133	.190	.238	.302
500	.170	.243	.307	.389
800	.213	.306	.388	.491
1000	.237	.341	.432	.548
1200	.258	.373	.473	.600
1600	.294	.428	.544	.691
2000	.325	.475	.605	.771
2400	.351	.517	.661	.842
2800	.375	.555	.711	.908
3000	.385	.573	.734	.938
3200	.396	.590	.757	.968
3500	.410	.614	.789	1.011
3800	.423	.637	.820	1.051
4000	.432	.652	.840	1.077
4200	.440	.666	.859	1.102
4500	.451	.686	.887	1.139
4800	.462	.705	.913	1.174

TABLE 5-5
NONLOADED CABLE ATTENUATION CHARACTERISTICS
(DECIBELS/KFT AT 88° F.)

Frequency (Hz)	19 GA	22 GA	24 GA	26 GA
200	.111	.158	.199	.252
300	.136	.193	.244	.308
500	.174	.249	.314	.397
800	.218	.313	.396	.502
1000	.242	.349	.442	.560
1200	.264	.381	.483	.613
1600	.301	.437	.556	.706
2000	.332	.486	.619	.788
2400	.360	.529	.676	.861
2800	.384	.568	.727	.928
3000	.395	.586	.751	.959
3200	.406	.604	.774	.990
3500	.421	.629	.808	1.033
3800	.435	.652	.839	1.075
4000	.444	.667	.859	1.101
4200	.452	.682	.879	1.127
4500	.464	.703	.907	1.165
4800	.475	.722	.935	1.201

TABLE 5-6
H-88 LOADED CABLE ATTENUATION CHARACTERISTICS
(DECIBELS KFT AT 68° F.)

Frequency (Hz)	19 GA	22 GA	24 GA	26 GA
200	.072	.121	.169	.222
300	.074	.132	.191	.256
500	.077	.141	.213	.298
800	.080	.148	.228	.330
1000	.080	.150	.231	.341
1200	.081	.150	.233	.347
1600	.081	.150	.235	.352
2000	.081	.150	.235	.354
2400	.085	.152	.237	.354
2800	.093	.161	.246	.362
3000	.102	.169	.260	.375
3400	.203	.261	.432	----
3500	----	----	----	.570

Exercises (832):

1. DC loop resistance of a 19-gauge cable, 5,000-feet long, at 68° measures 82 ohms. Is it good or bad?

2. The cable in question 1 has an insulation resistance of 793 Mohms. Is it good or bad?

3. A cable pair has 83 hits at 58 dBrnc on an impulse noise test. Is it acceptable for voice?

4. What are the impulse noise limits for data circuits?

5. What values of idle channel noise test would be entered on the AFTO Form 485 in red?

6. On loaded cable, measured facility loss compared to calculated value must be within _____ _____ at 1,000 Hz and 2,000 Hz and _____ _____ at 300, 500, and 3,000 Hz.

7. A station ground has to be less than _____ ohms to be acceptable.

NOTE: Page 620 has been omitted.
However, all course material is included.

ANSWERS FOR EXERCISES

CHAPTER 1

Reference:

800 - 1. Direct dial, being able to directly dial the desired number. Operator assistance, placing the call through the operator.

800 - 2. Dual tone multifrequency.

800 - 3. Five.

800 - 4. To provide information assistance, establish conferences, and place precedence call for AUTOVON users.

801 - 1. Seven.

801 - 2. A network consists of the AUTOVON switching centers, and the trunks connecting them to central offices and other AUTOVON switching centers; all within one geographic area.

801 - 3. To indicate the precedence of the originating call.

801 - 4. The call is routed to a recorded announcement.

802 - 1. The amount of equipment installed and its placement for ease of maintenance.

802 - 2. An SF signaling unit is a complete, self-contained 2,600 Hz in-band signaling system. Its purpose is to mark the interoffice trunks idle or to provide trunk supervision.

802 - 3. On the central office or equipment side of the SF unit there are two pieces of equipment; the terminating set or hybrid coil connects the transmit and receive pairs to it and the trunk circuit connects the E and M leads to it. On the line side the SF unit connects the transmit and receive pairs to the VF line amplifier.

802 - 4. On outgoing calls from the control office the SF unit converts the dial pulses to 2,600 Hz tone bursts. On incoming calls the SF units converts the incoming signal, via the E lead, to the trunk circuit in the form of dial pulses.

802 - 5. The foreign applique is used to convert the signaling used in the foreign equipment to loop pulsing are required by the two-wire/four-wire trunk.

803 - 1. Ground through contacts 4B and 5B of the operated CNS relay in the trunk circuit is sent back to hold the outgoing selector operated via the C lead.

803 - 2. The SF unit is alerted that the trunk circuit is no longer idle when contacts 4 and 5 of the operated A relay in the trunk circuit removes ground potential from the E lead and contacts 5 and 6 of relay A place resistance battery on the E lead.

803 - 3. On the second or subsequent impulse make relay A in the trunk circuit operates closing a holding path to relay B, an operate path to relay AS, places resistance battery on the M lead, and opens the path to the C relay, which places it on slow-to-release.

803 - 4. The closing of contacts 2 and 3 of the ES relay causes relay PT and SR to operate in parallel. If this call were placed through the switchboard, the cord busy lamp would extinguish.

803 - 5. The ONS relay is the last relay to release when the called party hangs up. The contacts, 4B and 5b of the operated ONS relay keep a ground on the C lead back to the preceding equipment to mark the trunk busy.

804 - 1. The lead SF unit, when it stops receiving 2,600 Hz tone from the distant office (AUTOVON), changes the condition of the E lead to the trunk circuit from an open to a ground potential, causing the E relay.

804 - 2. The operation of relay IN in the trunk circuit seizes the incoming selector during an NID call.

804 - 3. The operation of the INS relay, contacts 2 and 3, places ground on the HU lead to mark the trunk busy when rotary switch access is used.

804 - 4. The closed 5 and 6 contacts of relay DE (fig. 2A on foldout 3) keep a loop across tip and ring of the incoming selector during the receipt of the first (precedence) digit; since the loop remains, the selector does not step.

804 - 5. The RS1 (rotary switch) will step in response to the digit dialed (precedence) to indicate what the precedence of the call is: 1, 2, 3, 4, or 0.

804 - 6. The opening and closing of relay E contacts 6 and 7 steps the incoming equipment.

804 - 7. The opening of off-normal (ON) contacts 1 and 2, when RS1 reaches home position, opens the homing circuit, when the trunk circuit is releasing from an NID call.

805 - 1. The obvious problem is that no ground is being returned by the trunk to mark it busy to other selectors. Contacts 5B and 6B of relay P35 are dirty, or the contacts of the busy key are dirty. If it was accessed from a rotary switch, by the second party, contacts 6B and 7B of the ONS relay or the busy key contacts are dirty. Burnishing the contacts will clear the trouble.

805 - 2. The shunt provided by contacts 5 and 6 of relay DE is missing, probably due to dirty contacts. Burnishing the contacts should cure the trouble.

805 - 3. It would appear that contacts 10B and 11B of relay ONS are dirty or failed to make. They require burnishing or adjusting.

805 - 4. The WK relay is not operating, the probable cause is that contacts 3 and 4 of the B2 relay are dirty and require burnishing. It might also be that the WK relay is out of adjustment and requires readjustment, but this is less likely.

CHAPTER 2

806 - 1. The precedence busy lamp lights due to the operation of the PSL relay, which operates due to operation of relay JP in the switchboard applique circuit.

806 - 2. The trunk is made busy to distant subscribers by operation of relay H in the trunk circuit, which changes the condition of the M lead to off-hook. It is made busy to local first selector rotary switch access by operation of relay ONS, which places ground on the C lead and the HU lead.

806 - 3. The operator knows that the called party of a PNOD call has answered the call when the cord supervision lamp goes out. The cord supervision lamp goes out due to the operation of relay RV in the trunk circuit, which operates when the condition of the E lead is changed, causing

relays E, ESS, ES, SR, and PT to operate. The operation of relay PT closes the operate path of the RV relay.

806 - 4. The busy lamps on the switchboard remain lit until the PBY relay releases; this happens at the very end of the circuit actions that occur when the called party hangs up and, in turn, changes the condition of the E lead in the local trunk. Just prior to the above actions, relays ONS and PSL release, removing the ground potential from the C lead to the selectors and the HU lead to the rotary switches.

806 - 5. The precedence busy lamp is lit from ground on the contacts of relay PSL. Relay PR operates prior to the release of relay PSL, providing an alternate path for the busy lamp until the trunk is released from both ends.

806 - 6. When DTMF keyset button 6 is depressed and the contacts beneath it make, causing a tone of 770 hertz + 1477 hertz to be sent to the AUTOVON switch on your transmit pair.

807 - 1. When relay AR operates, it closes contacts 6T and 7T and 8B and 9B, sending precedence ringback tone to the calling party.

807 - 2. The timer, 12 to 15 seconds after it starts timing, places ground on its output terminal (7) to operate the RBL relay; this causes the precedence answer lamp to flash at a rate of 60 IPM.

807 - 3. When the operator answers a diverted PNID call, by plugging an answer cord into the precedence jack, a ground is placed on lead K, which operates relay JP.

807 - 4. During a PNID call, the central office equipment steps in response to the breaking and making of contacts 6 and 7 of relay E in the trunk circuit. The E relay operates and releases in response to the pulses of ground on the E lead from the SF unit.

807 - 5. The condition of the M lead in the trunk circuit, for a diverted PNID call, changes to off-hook when relay A operates; this occurs after the operator answers the call.

807 - 6. The contacts that provide relay JP in the applique circuit with its hold path are the same as those that caused it to operate. They are located in the precedence jack, one connected to ground and the other, to lead K.

808 - 1. The trouble is that contacts 5 and 6 of relay A are open. Burnishing the contacts will clear the trouble.

808 - 2. Contacts 5 and 6 of relay DE are open, which eliminates the shunt on contacts 6 and 7 of relay E. Burnishing the contacts of relay DE should solve the problem.

808 - 3. Diode CR5 is open, preventing the ground from contacts 12B and 13B of relay PBY from reaching the BL1 lead. CR5 must be replaced.

808 - 4. The most probable cause of trouble is dirty contacts 6 and 7 of relay E. Burnishing the contacts should clear the trouble.

808 - 5. Contacts 5T and 6T of relay JP are dirty. Burnishing the contacts will clear the trouble.

809 - 1. Break contacts 1 and 2 of the ON1 relay when it releases make to operate relay ON3.

809 - 2. The slow discharge of capacitor C1 keeps relay ON2 on slow-to-release.

809 - 3. Break contacts 5 and 6 of an operated ON3 relay removes battery from the C2 lead, preventing premature seizure by a selector for an NOD call.

809 - 4. Open contacts 1 and 2 of operated relay ON3 prevent the operator from initiating a routine call prior to complete release of the circuit from another call.

809 - 5. When the called party answers an NID call, a 750-ohm battery is placed on lead b1 through the S relay to ground, operating it. When relay S operates, battery is reversed to the trunk circuit; this causes the SP relay in the trunk circuit to operate. The other make contacts of relay S increase the capacitance on both sides of the transmission path from 2 mf to 8 mf.

809 - 6. When relay C releases, its 10 and 11 contacts break, removing the shunt from the AC winding of relay and allowing it to operate fully.

810 - 1. During seizure the selector places ground on the C2 lead of the applique circuit, operating the N relay.

810 - 2. During an NOD call, contacts 1 and 2 of relay A3 transmit the pulses to the trunk circuit.

810 - 3. During an NOD call, the low resistance ground at lead C2 marks this circuit busy to other local selectors.

810 - 4. When the called party answers during an NOD call, battery from the trunk circuit is placed on the SPS lead, operating relay S2.

811 - 1. There are three possible sets of dirty contacts; 5 and 6 of relay BJ, 1 and 2 of the rotary switch cam switch (MR), or 1 and 2 of the motor magnet interrupters (MM). Burnishing the dirty set of contacts will clear the trouble.

811 - 2. The A2 relay is not operating because contact 23 and 24 of relay R or contacts 1 and 2 of relay S2 are dirty. Burnishing the dirty contacts will clear the trouble. Contacts 1 and 2 of relay A3 could be shorted, but dirty contacts are more probable.

811 - 3. This trouble has to be a broken wire in the bank multiple or a cold solder joint at the C2 lead. Replacing the wire or resoldering the bad joint will clear the problem.

811 - 4. The trouble here is that the ON3 did not operate, because the ON2 relay released immediately. Replacing capacitor C1 should solve the problem.

812 - 1. With the trunk circuit idle, the K1 relay (ASC unit) is operated in the SF unit.

812 - 2. During an NOD call, the condition of the M lead changes from ground to battery, causing relay K1 to release and removing the 600-ohm idle line termination from the XMIT side of the outgoing line as well as the 2,600-Hz tone.

812 - 3. When 2,600-Hz tone is not received from the distant end, the K1 relay of the SF unit (control unit) operates, placing ground on the E lead to the trunk; this operates the trunk circuit relay E.

812 - 4. Diode CR3 is in the path that operates the K1 relay in the SF unit (osc unit).

813 - 1. A VF line amplifier consists of two identical circuits. A transmit amplifier circuit and a receive amplifier circuit.

813 - 2. The impedance network tends to form a constant impedance so that, regardless of the position of R2 and R4, the input impedance remains almost constant.

813 - 3. The low-pass filter restricts the bandwidth to that of the normal voice band.

814 - 1. Either resistor R16 or diode CR3 are open, preventing the K1 relay from operating. Replacement of the bad component should clear the trouble.

814 - 2. The reason there isn't a 600-ohm termination across the transmit side of the line is one of two things: (1) resistor R19 has burned out in a short or contacts of the K1 relay (osc unit) are open and (2) replacement of the resistor, if bad, or replacement of the mercury relay, if the contacts are open, should cure the trouble.

814 - 3. The trouble is probably that resistor R36 is open and needs to be replaced.

CHAPTER 3

815 - 1. The purpose of the noise and balance test line circuit is to test a line for return loss and singing, as well as transmission measurement.

815 - 2. The reverse battery test line circuit is used for testing the supervisory functions of the PABX trunk circuits and interface equipment.

815 - 3. The purpose of the end office loop around test circuit is to make circuit stability and loop around (receive and transmit loss) tests.

815 - 4. The connector access number of the noise and balance test line circuit is 41.

815 - 5. The end office loop around circuit provides 3 terminations: (1) 10 seconds of open circuit line termination, with 1 second of 900-ohm 2-microfarad line termination; (2) 10 seconds of short circuit line termination; and (3) 900-ohm 2-microfarad line termination.

816 - 1. During release of the noise and balance test line circuit, ON contacts 1 and 2 provide for the self-interrupted return of the rotary switch to the home position.

816 - 2. If Z wiring option were used in place of Y wiring option, the termination would be 4 mf and no resistance.

816 - 3. Tube terminals 7 and 1 of a conducting T1 tube provide the low resistance bridge across the line to cut off ringing in the connector.

816 - 4. The 48 volts superimposed on the ringing current causes the tube T1 to conduct.

817 - 1. The termination provided to the connector by the reverse battery test line circuit during seizure is 2,000-ohms and 2 mf.

817 - 2. The D relay operates first from ground on the C wiper of the connector.

817 - 3. During the second ringing cycle the A relay reoperates, closing a path to relay B. Contacts 9 and 10 of relay B close a path to the rotary switch; this operates but does not step.

817 - 4. Contacts 2 and 3 of relay D provide the ground to operate the rotary switch the third time.

817 - 5. The G relay operates when the rotary switch releases for the third time and steps to the third contact. It operates to the ground at contacts 2 and 3 of the operated relay D.

817 - 6. Relay E must be operated in order for dial tone to be returned to the connector. Relay E operates when relay F is operated and when the rotary switch releases moving its wipers to contact 9.

818 - 1. The end office loop around test circuit enables the AUTOVON technician to make one-way and two-way transmission test on each access line without the assistance of the PABX attendant.

818 - 2. The line termination to AUTOVON, when the connector switches through to terminal 1, is 900 ohm 2 microfarads; when it switches through to terminal 2 the termination is 900 ohm 16 microfarads.

818 - 3. During a stability test, the T1 relay releases every time that the rotary switch TS is in the home position and its ON contacts 3 and 4 are not made.

819 - 1. Connector terminal No. 2 is used to establish known dB loss.

819 - 2. The 1,000-Hz test tone is transmitted at 0 dB.

819 - 3. Resistors R5 through R9 do not affect the 1,000-Hz test tone when the dB loss is being established, because relay T1 contacts 4B and 5B are open.

820 - 1. During the loop around test, the ring of terminals 1 and 2 are connected by contacts 5B and 6B and 5T and 6T of relay T1 and contacts 5 and 6 of relay LAC. The tip of terminals 1 and 2 are connected by contacts 2B and 3B and 2T and 3T of relay T1 and contacts 2 and 3 of relay LAC. Terminal 1 must be accessed prior to terminal 2 to perform the loop around test.

820 - 2. Rotary switch TS interrupter contacts 1 and 2 provide the ground that allows it to step automatically to the home position.

821 - 1. The VTVM, with respect to AUTOVON interface equipment, is used to measure decibels and voltage.

821 - 2. The control signal generator is used primarily to check the indialing capability of interface equipment without the assistance of AUTOVON switch personnel.

821 - 3. The electronic counter is used to measure frequency.

821 - 4. The signaling test set has a meter which tells you the speed of the pulses being received by your equipment and at what percentage of make and break the pulses allow you to adjust bias control of the SF signaling set.

821 - 5. The CSG allows you to test your trunks indial and outdial capabilities with help from the distant end, while the signaling test set requires people at both ends.

821 - 6. The audio oscillator produces the tones necessary for testing and aligning the interface equipment.

822 - 1. A type 1, operational check, PMI is to be used to check the output of the DTMF keyset. The use of an electronic counter is used to check the period of specified combinations of depressed buttons and a VTVM to check signal output level. You would take this approach, since no other position is complaining of a similar problem, and the DTMF keyset is the most logical source of trouble. If you should find a problem in the keyset, then you should perform a type 2 PMI and align it as necessary.

822 - 2. A type 2 PMI (alignment and adjustment) must be performed. You will use an audio oscillator and a VTVM, as well as the test leads and terminating plugs, as outlined in the tech order. This is the only logical approach to take.

823 - 1. To adjust the precise tone supply you will need an electronic counter and VTVM.

823 - 2. DTMF keyset.

823 - 3. SF signaling set.

CHAPTER 4

824 - 1. Trunk plant and distribution plant.

824 - 2. By solid lines, which may be interspersed with rectangles which represent manholes.

824 - 3. Underground cables are those installed through conduits, buried cables are planted directly into the ground.

824 - 4. Aerial cables are represented by solid lines; buried cable is represented by broken lines.

825 - 1. 01 to 99.

825 - 2. With the main feeder number plus a 2-digit suffix.

825 - 3. Cable pairs designation.

825 - 4. By the letter T and the building number.

825 - 5. They are marked on the map "TELCO."

826 - 1. Series inductance and shunt capacitance.

826 - 2. Size of the wires and center-to-center distance between the wires.

826 - 3. Shunt conductance or leakage.

826 - 4. Resistance and series inductance.

826 - 5. Maximum power transfer occurs when the impedance of the receiver, source, and the line are all matched.

826 - 6. Loading coils are added to transmission lines to increase series inductance of the line. This, in turn, reduces both attenuation and frequency distortion.

827 - 1. Hum.

827 - 2. Impulse.

827 - 3. Crosstalk.

827 - 4. Noise to ground.

827 - 5. Crosstalk.

827 - 6. White and impulse noise.

827 - 7. By using shielded cross connects.

828 - 1. None.

828 - 2. Frequency.

828 - 3. None.

828 - 4. Frequency and phase.

828 - 5. Reduced.

CHAPTER 5

829 - 1. AN/PSM-2A.
829 - 2. Idle channel noise test.
829 - 3. Station ground resistance test.
829 - 4. Impulse noise test.
829 - 5. Frequency response test.
829 - 6. DC loop resistance.
829 - 7. HP236A and HP3555B.

830 - 1. Cable map.
830 - 2. 4.
830 - 3. Idle channel noise test, impulse noise test, and frequency response test.
830 - 4. Cable number and pair number.
830 - 5. When different gauge cable is spliced into cable paired being tested.

831 - 1. Operator E handcrank generator.
831 - 2. Short together.
831 - 3. Discharged.
831 - 4. 15 minutes.
831 - 5. 50 dBrn.
831 - 6. 600 ohm.
831 - 7. Adjust range switch until they do.
831 - 8. Test oscillator HP 236A.
831 - 9. Grounding electrode or station ground.
831 - 10. Low 0 dBrn
Mid 4 dBrn
Hi 8 dBrn
831 - 11. If cable is loaded or nonloaded.

832 - 1. Good.
832 - 2. Good.
832 - 3. Yes, less than 90 hits.
832 - 4. 15 Hi hits, 15 minutes at 72 dBrnc.
832 - 5. Noise level is greater than 40 dBrnc.
832 - 6. 10 percent; 20 percent.
832 - 7. 5.

AU GAFS, AL (801046)1100

36251 05 S01 7606

SUPPLEMENTARY MATERIAL

CDC 36251

TELEPHONE SWITCHING EQUIPMENT REPAIRMAN (ELECTROMECHANICAL)

(AFSC 36251)

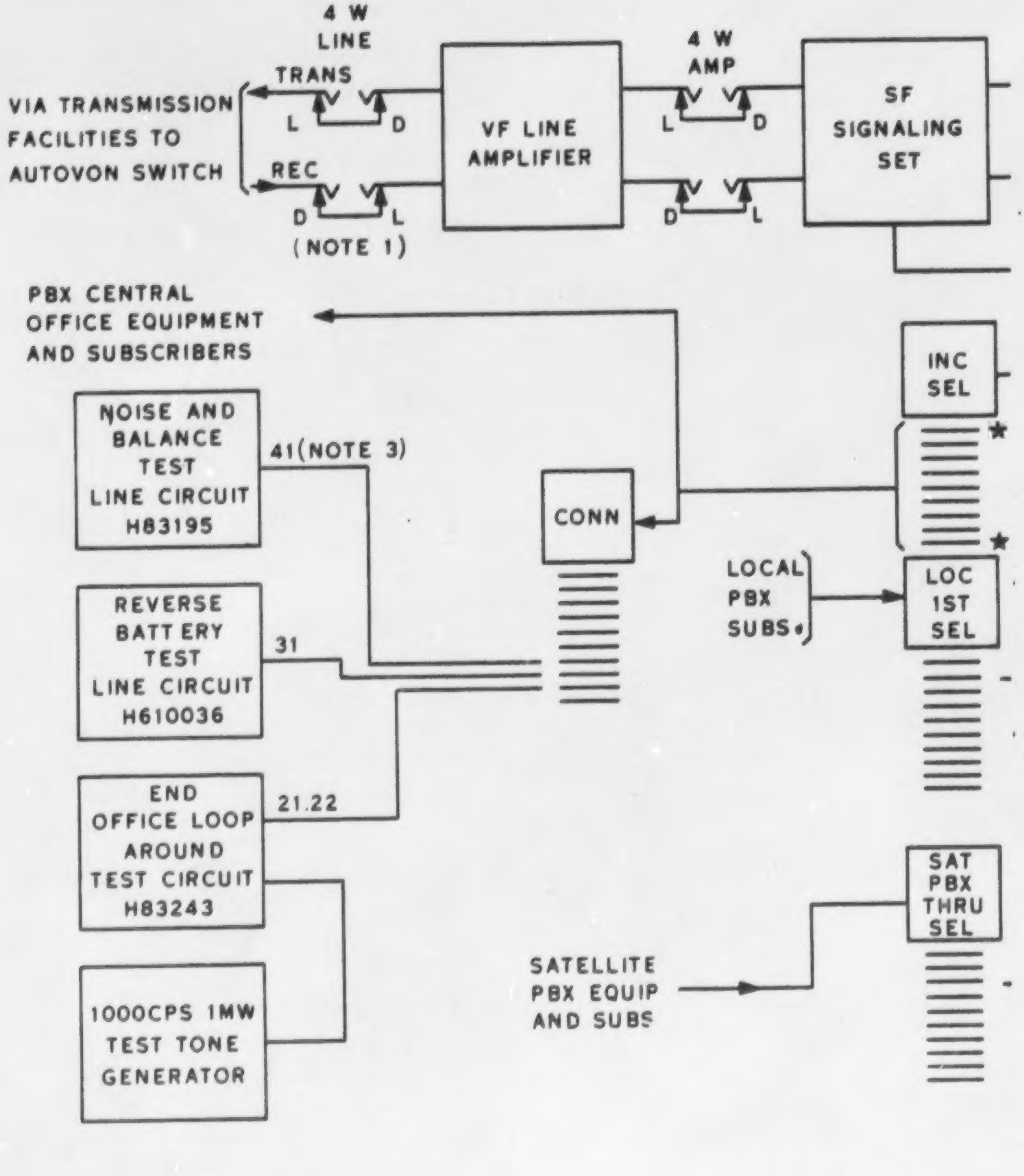
Volume 5

AU GAFS, AL (801047)1100

Foldouts 1, 4 through 10

(Foldouts 2 and 3 are separate enclosures)

Extension Course Institute
Air University


4 W
LINE
TRANS
REC
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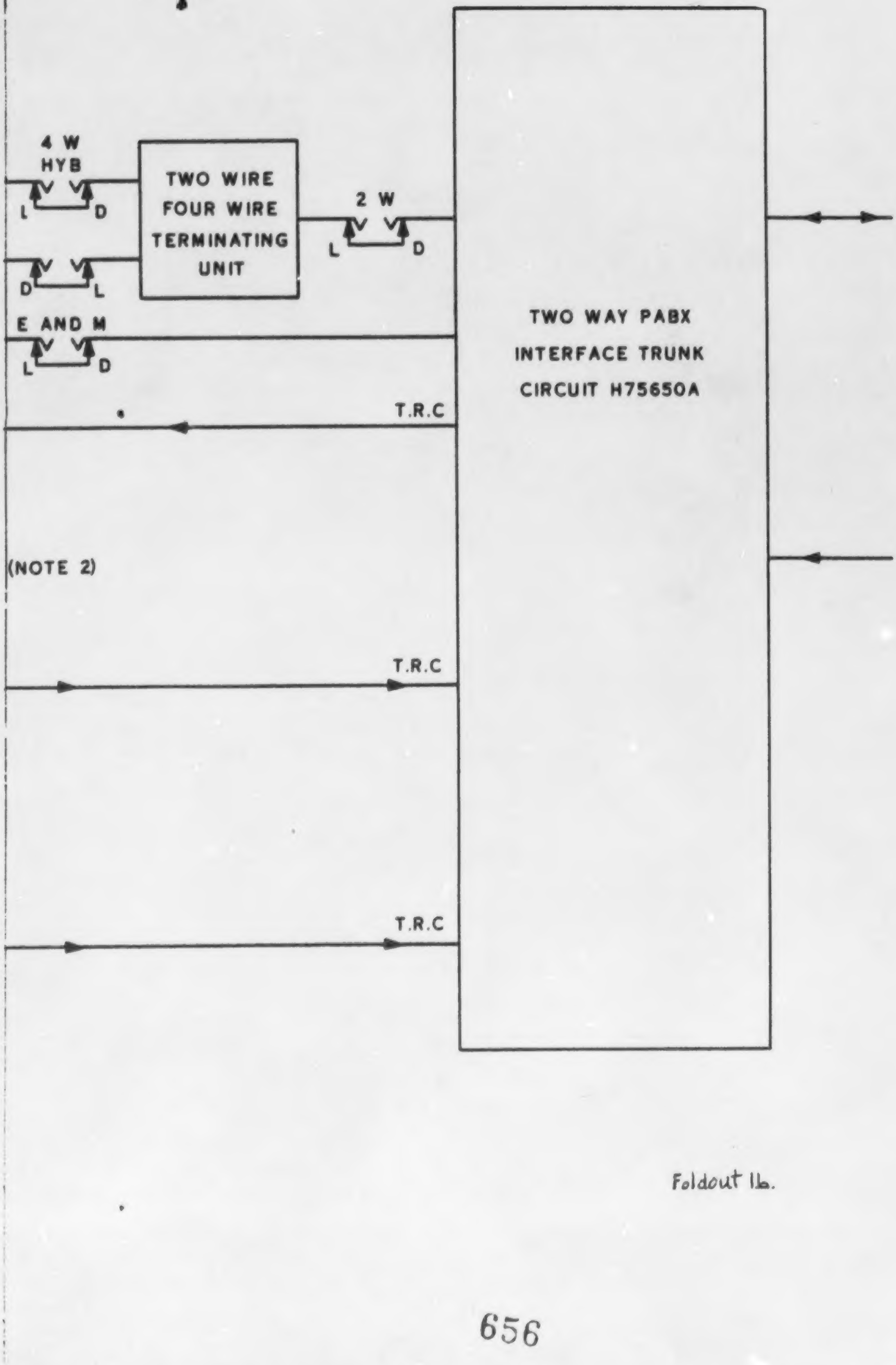
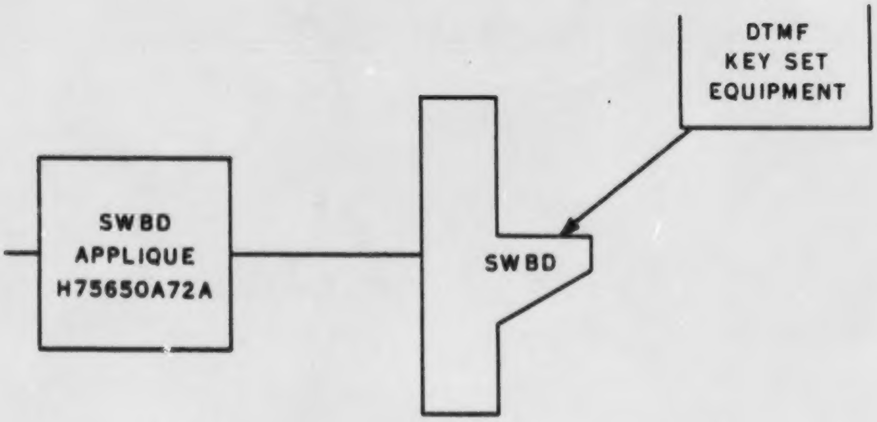
D
D
L
(NOTE 1)
VIA TRANSMISSION FACILITIES TO AUTOVON SWITCH
VF LINE AMPLIFIER
4 W
AMP
L
D
D
L
SF SIGNALING SET
PBX CENTRAL OFFICE EQUIPMENT AND SUBSCRIBERS
INC SEL
NOISE AND BALANCE TEST LINE CIRCUIT H83195
41(NOTE 3)
CONN
★
★
LOCAL PBX SUBS.
LOC 1ST SEL
REVERSE BATT ERY TEST LINE CIRCUIT H610036
31
END OFFICE LOOP AROUND TEST CIRCUIT H83243
21.22
SAT PBX THRU SEL
SATELLITE PBX EQUIP AND SUBS
1000CPS 1MW TEST TONE GENERATOR

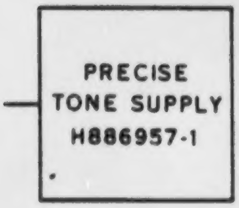
Foldout 1a.

627



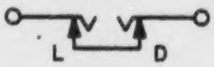
Foldout 1b.

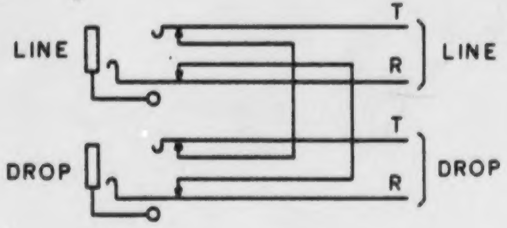




NOTES

2.★DENOTES DIGIT CANCEL ON LEVEL ONE AND RELEASE OF SELECTOR ON "0" LEVEL WHEN DIALING XXX-1110 FOR OPERATOR ASSISTANCE

1.  TEST JACK ASSEMBLY WIRED AS BELOW



3. DENOTES LAST TWO DIGITS OF CONN ACCESS NUMBER FOR SPECIAL TEST CIRCUITS.

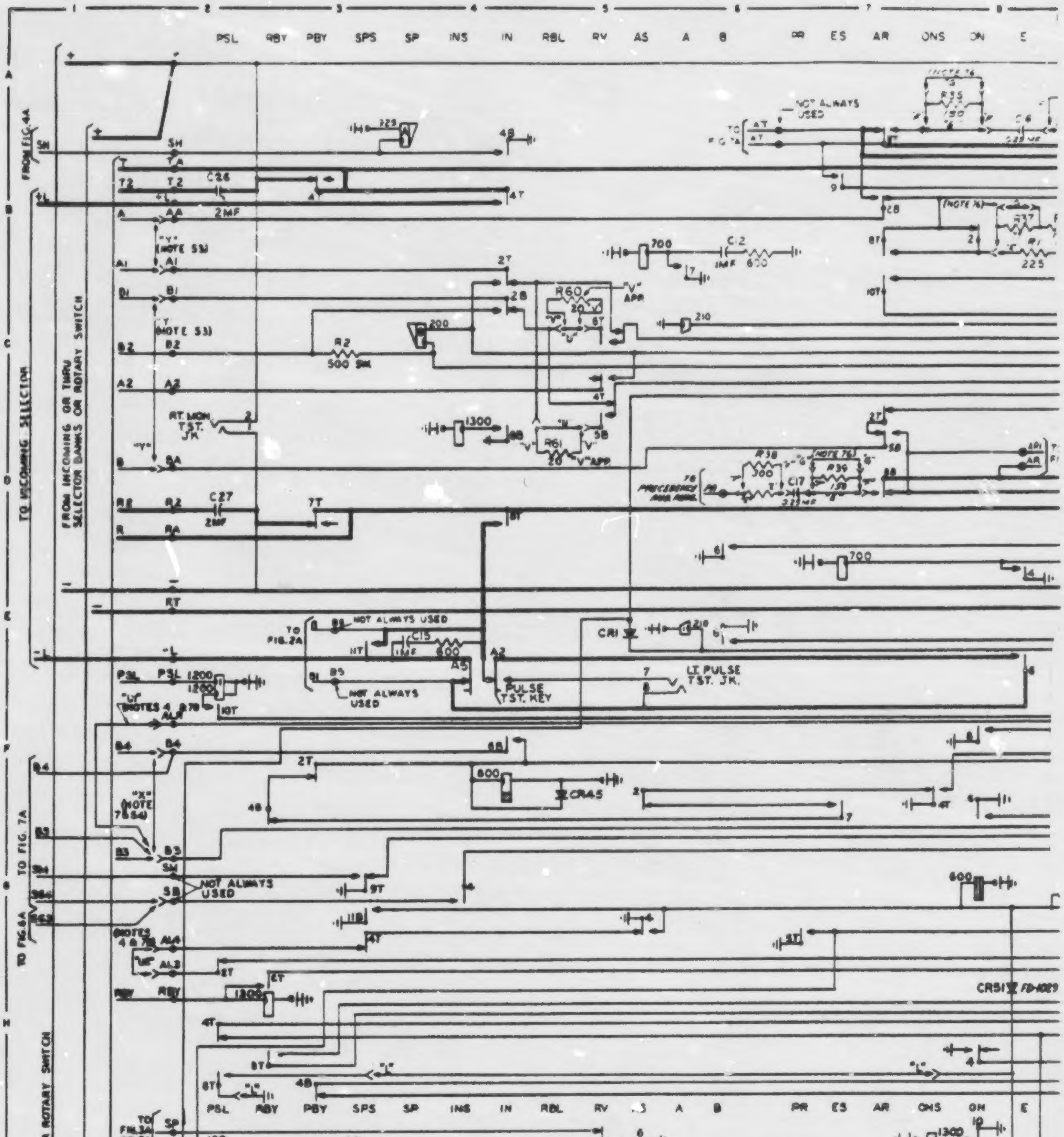
HANDOUT 1
3ABR36231-XV

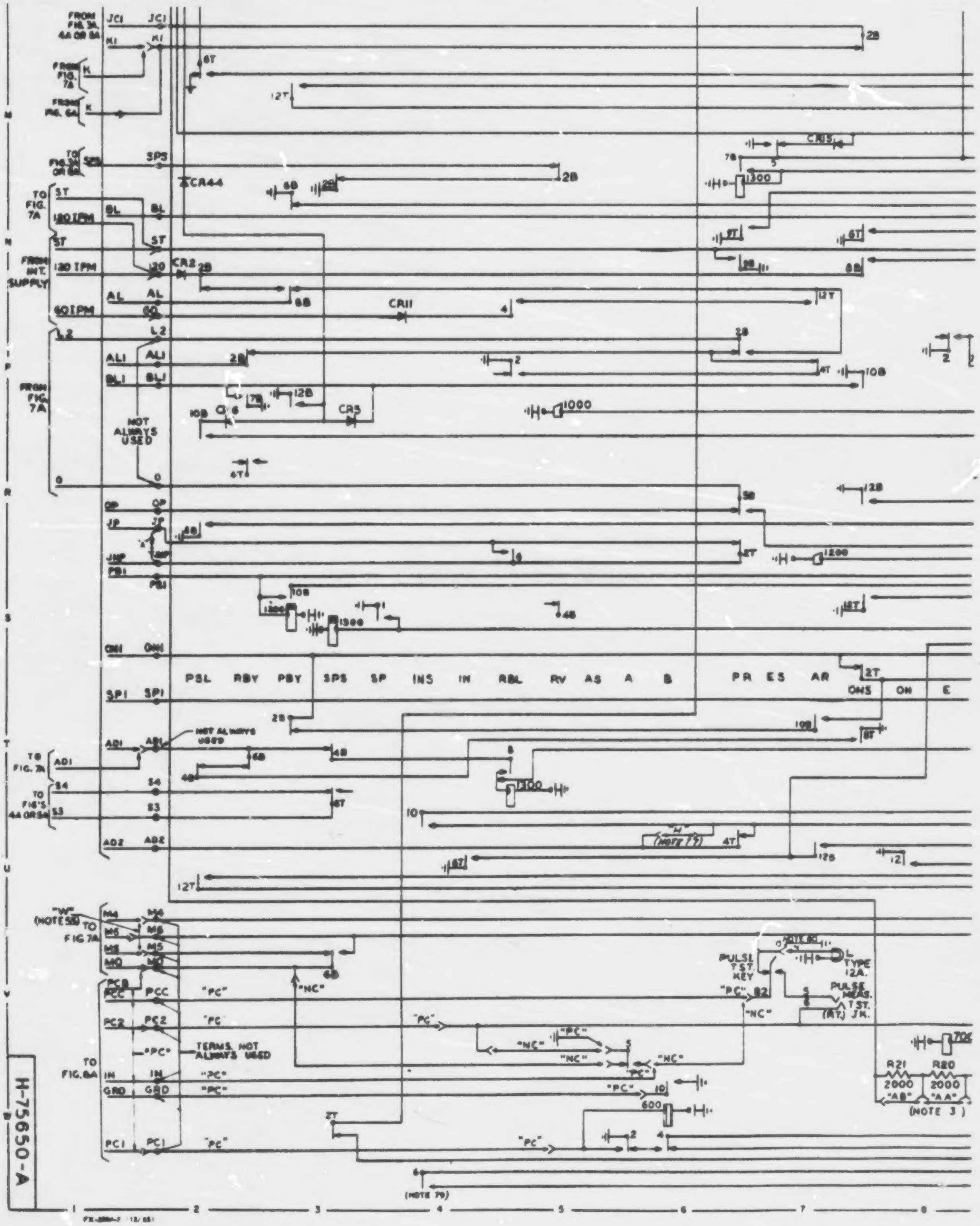
AUTOVON INTERFACE EQUIPMENT

Foldout 1c AUTOVON interface equipment.

629

Fo. 2
Top Left



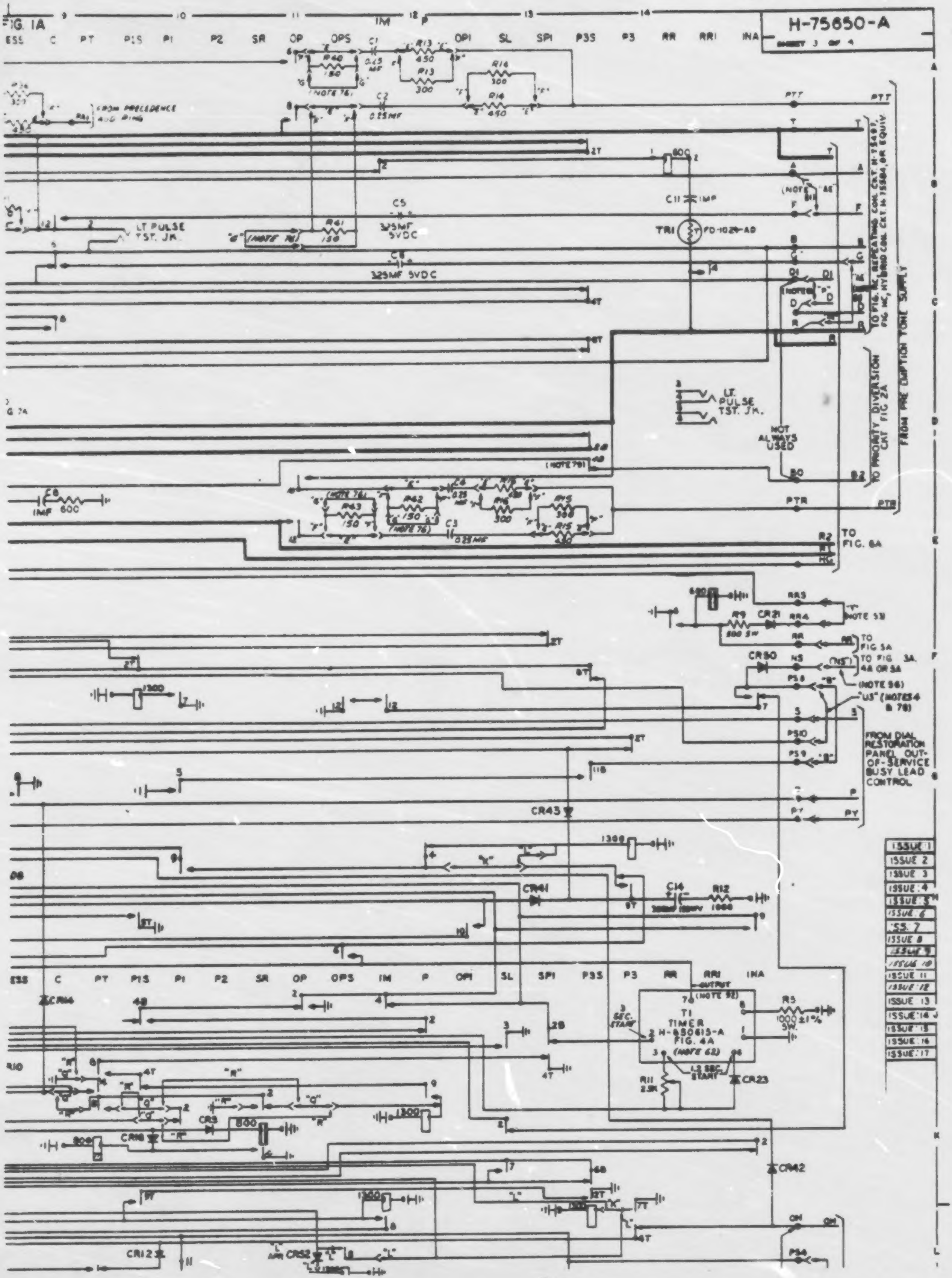


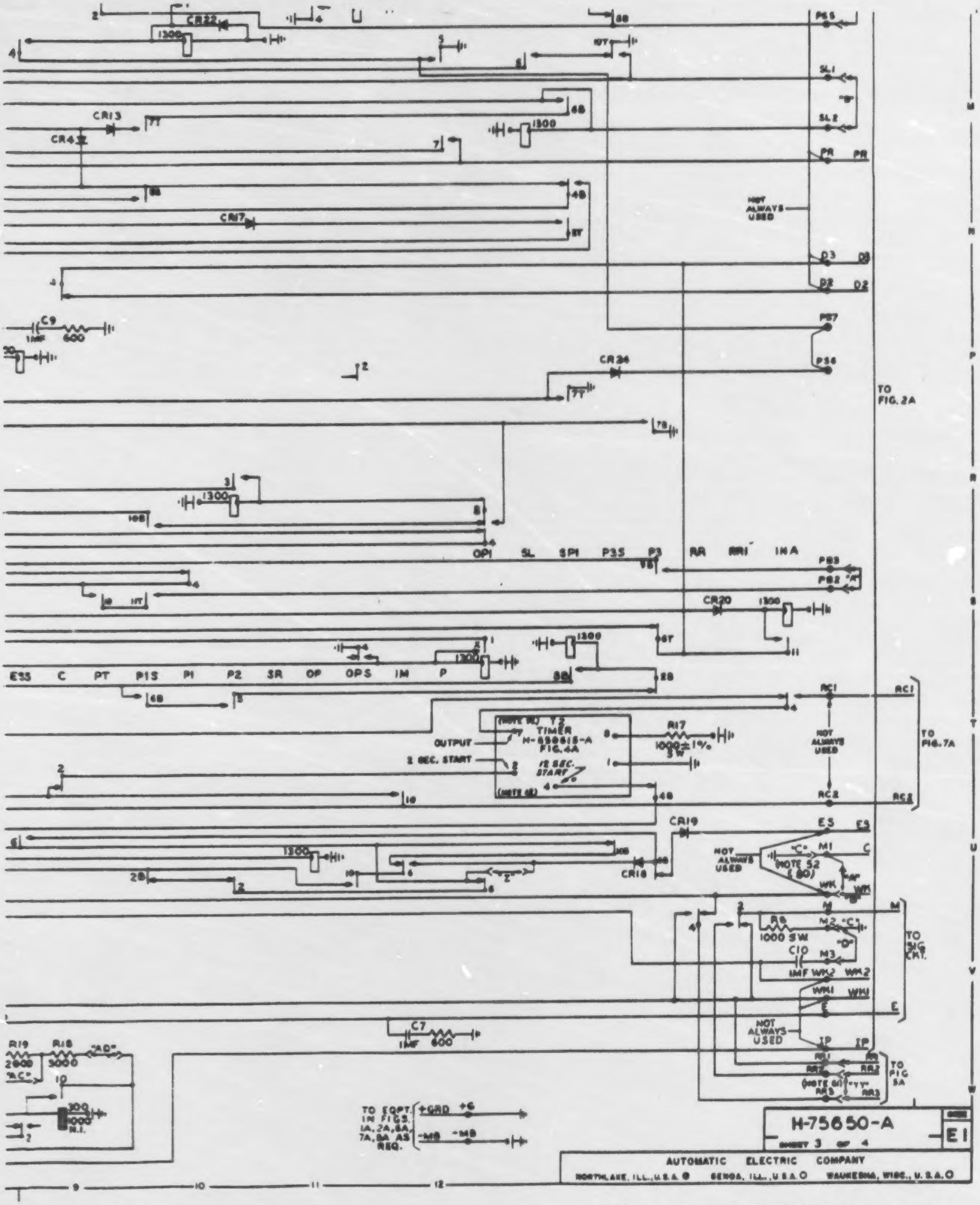
AU GAFS, AL. (791335)1000

630
FO. 2.
BTM LEFT

Fo. 2.
TOP RIGHT

631





Foldout 2. Two-way PABX interface trunk circuit.

632

661

BTM RIGHT

633

TABLE A (FIGURES)

FIG.	SUBFIGURES (TABLE B)												WIRING									FEATURES
	1A	2A	3A	4A	5A	6A	7A	8A					A		B		PC		NC			
21A	•												•						•			BASIC CKT. NO PULSE CORRECTION OUTGOING
22A	•	•													•				•			BASIC CKT. WITH PRIORITY DIVERSION
23A	•					•							•						•			BASIC CKT. WITH PAD CONTROL.
24A	•	•				•		•							•				•			BASIC CKT. WITH PAD CONTROL AND PRIORITY DIVERSION.
25A	•												•						•			BASIC CKT. WITH TRANSFER TO ATTENDANT
26A	•	•					•								•				•			BASIC CKT. WITH PRIORITY DIVERSION AND TRANSFER TO ATTENDANT.
27A	•	•				•	•								•				•			BASIC CKT. WITH PRIORITY DIVERSION TRANSFER TO ATTENDANT. PAD CONTROL.
28A	•							•					•				•					BASIC CKT. ELECTRONIC PULSE CORRECTOR.
29A	•	•						•							•		•					BASIC CKT. WITH PRIORITY DIVERSION AND ELECTRONIC PULSE CORRECTOR.
30A	•					•		•					•				•					BASIC CKT. WITH PAD CONTROL AND ELECTRONIC PULSE CORRECTOR.
31A	•	•				•		•							•		•					BASIC CKT. WITH PRIORITY DIVERSION. PAD CONTROL AND ELECTRONIC PULSE CORRECTOR
32A	•						•	•					•				•					BASIC CKT. WITH TRANSFER TO ATTENDANT AND ELECTRONIC PULSE CORRECTOR
33A			•																			PABX AND TOLL BOARD APPLIQUE
34A				•																		
35A					•																	
36A						•																PAD CONTROL CKT.
37A							•															TRANSFER TO ATTENDANT.
38A								•														PULSE CORRECTION CKT.
39A		•																				PRIORITY DIVERSION CKT.
40A																						
41A	•	•					•	•							•		•		•			BASIC CKT. WITH PRIORITY DIVERSION TRANSFER TO ATTENDANT AND ELECTRONIC PULSE CORRECTOR
42A	•					•	•	•							•		•					BASIC CKT. WITH PRIORITY DIVERSION TRANSFER TO ATTENDANT. PAD CONTROL AND ELECTRONIC PULSE CORRECTOR

TABLE B

PABX CORD CIRCUITS	SPECIFY FIGURE						
	3A	4A	5A				
UNIVERSAL	•						
SIMPLIFIED		•					
TYPE 30 & 31 TOLL SWBD			•				

TABLE C

OPTION	ISSUES		FIGURES	TABLES	NOTES	WIRED BY	
	FIRST USED	LAST USED				FACTORY	INSTALLER
A	1		1A	A	79	X	
B	1		1A	A	79	X	
C	1		1A		52	X	
D	1		1A		52		X
E	1	8	1A, 3A, 4A, 5A, 6A				
F	9		1A, 3A, 4A, 5A, 6A			X	
G	9		1A, 3A, 4A, 5A, 6A		3, 76		X
H	5		1A'		4, 77	X	
I	1	12	4A				
J	13		4A			X	
K	1	12	1A, 3A, 4A, 5A				
L	13		1A			X	
M	14		4A			X	
N	1		1A			X	
O	13		1A		80		X
P	13		1A		6	X	
Q	1	14	1A			X	
R	15						
S	1		4A		57	X	
T	1		4A		57	X	
U	1	16					
V	17						
W	1		1A		55	X	
X	1		1A		54	X	
Y	1		1A		53	X	
Z	16		1A			X	
U1	1		1A		4, 78	X	
U2	1		1A		4, 78	X	
U3	1		1A		4, 78	X	
U4	1		1A		4, 78	X	
AA	1		1A		3	X	
AB	1		1A		3		X
AC	1		1A		3	X	
AD	1		1A		3	X	
AE	17		1A		81		X
BS			1A		59	X	
NC			1A	A		X	
NS			1A, 3A, 4A, 5A		56		X
PC			1A	A		X	
PR			2A		58	X	
TY	1		1A		61	X	

Foldout 3a.

662

FIG. 2A

PRECEDENCE IN DIALING CONTROL CIRCUIT (PRIORITY DIVERSION)

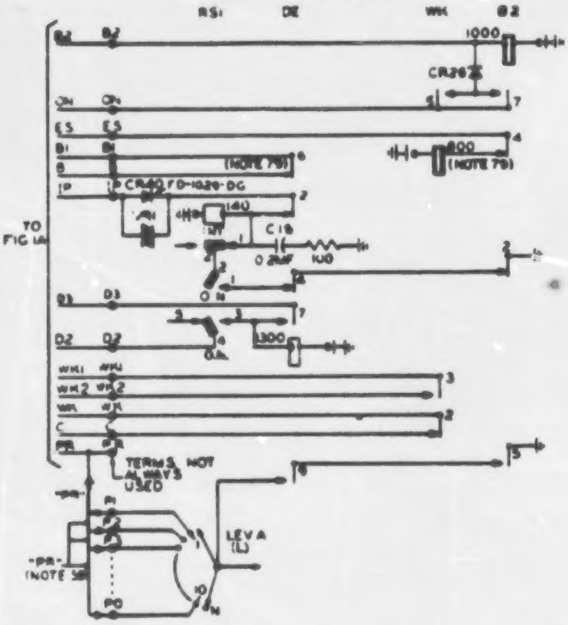


FIG. HC

HYBRID COIL CKT. (FOR REF. ONLY)

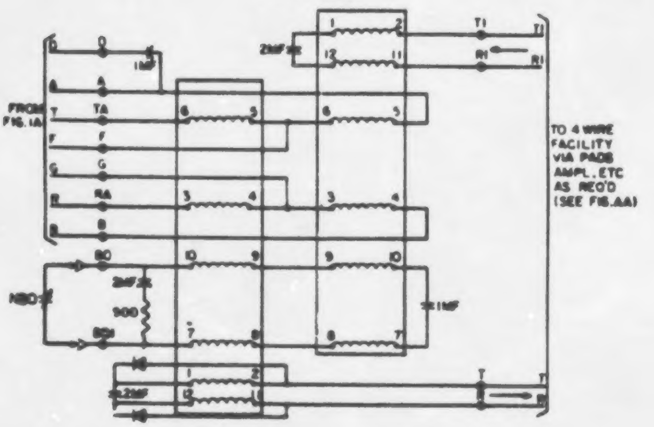

FROM FIG. 1A
T1
R1
TA
RA
2MF
NBO
900
TO 4 WIRE FACILITY VIA PADS AMPL. ETC AS REQ'D (SEE FIG. AA)
T
R

FIG. JK2

SWITCHBOARD PORT FOR UNIVERSAL & TOLL BOARDS (FOR REF. ONLY) DRWN AS H-53822 FIG. 54A

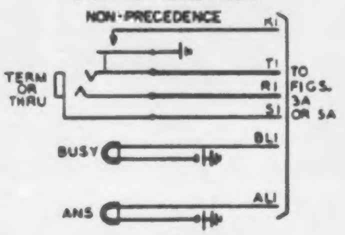


FIG. 3A

UNIVERSAL BOARD APPLIQUE

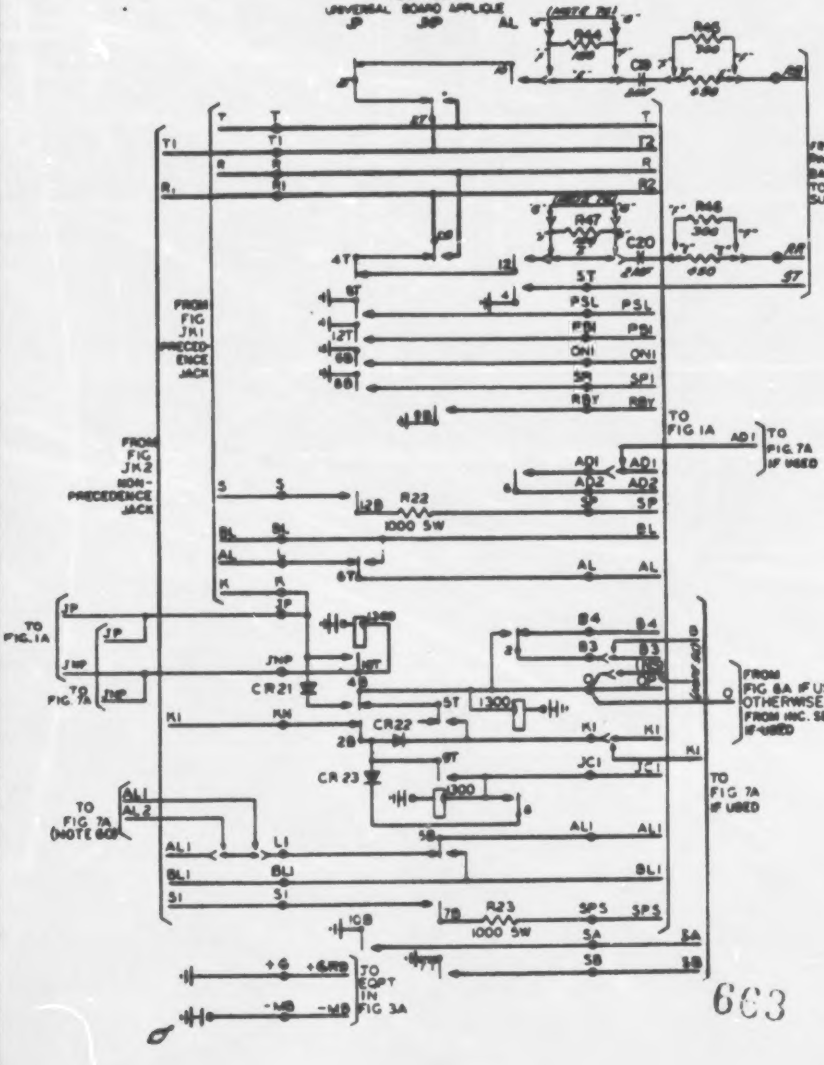
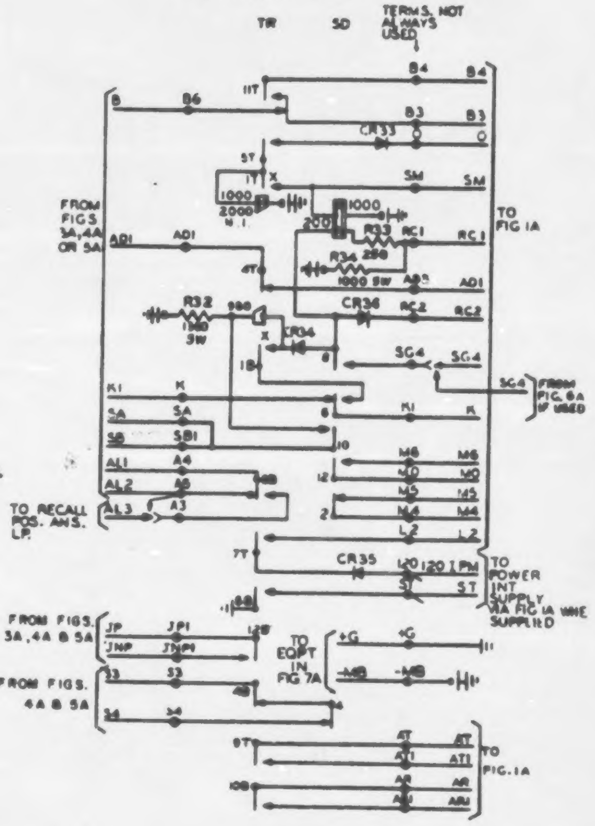


FIG. 7A

TRANSFER TO ATTENDANT



Foldout 3b.

INSTALLING NOTES:

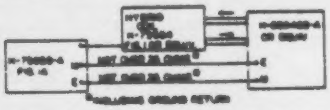
76 - EQUIPMENT LEAVES THE FACTORY WIRED FOR "900 OHM OFFICE". IN "600 OHM OFFICE", ADD WIRING "G".

77 - IF STATIONS DO NOT DIRECTLY DIAL INWARD NOR OUTWARD (ATTENDANT HANDLES ALL TRUNKED CALLS). IN FIGURE 1A REMOVE WIRING "H".

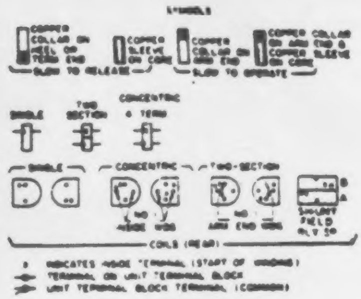
78 - IF H-75650-A IS USED WITH EQUIPMENT NOT MADE IN THE UNITED STATES OF AMERICA. YOU MAY HAVE TO REMOVE ALL 4 STRAPS-- U1. U2. U3. and U4.

79 - WHEN FIGURE 2A IS EQUIPPED. BUT INCOMING SELECTOR IS NOT USED. IN FIGURE 1A: REMOVE STRAPS "B" AND ADD STRAPS "A". DISCONNECT AND INSULATE THE WIRE AT RELAY PSS SPRING 4B. AND THE WIRE AT RELAY DIS SPRING 6. IN FIGURE 2A: DISCONNECT AND INSULATE THE WIRE AT RELAY WK "IN" COIL TERMINAL. AND THE WIRE AT RELAY DE SPRING 6.

80 - WHEN H-75650-A IS CABLED DIRECTLY TO NEARBY H-850420-A OR EQUIVALENT WITHOUT CARRIER. OR SIGNAL CIRCUIT. REMOVE WIRINGS "C" & "H" AND ADD WIRING "O" THE GROUND POTENTIAL DIFFERENCE BETWEEN UNITS MUST BE NEGLIGIBLE.



81 - WHEN REPEATING COIL PER FIGURE RC CIRCUIT H-75497 OR EQUIVALENT IS SPECIFIED. OMIT STUBBINGS F & G. AND ADD WIRING "AE".



SYMBOLS
COPPER COLLAR ON HEEL OR TERM END
COPPER SLEEVE ON CORE
COPPER COLLAR ON ARM END
COPPER COLLAR ON ARM END & COPPER SLEEVE ON CORE
SLOW TO RELEASE
SLOW TO OPERATE
SINGLE
TWO SECTION
CONCENTRIC 4 TERM
SINGLE
CONCENTRIC
TWO-SECTION
INSIDE WDG
ARM END WDG
SHUNT FIELD
COILS (REAR)
INDICATES INSIDE TERMINAL (START OF WINDING)
TERMINAL ON UNIT TERMINAL BLOCK
UNIT TERMINAL BLOCK TERMINAL (COMMON)

MANUFACTURING NOTES:

1 - CONTACTS "X" MAKE FIRST.

2 - ISSUES 1-11. ALL DIODES WERE FD-1029-DF. ISSUES 12 & LATER. ALL DIODES NOT OTHERWISE SPECIFIED ARE FD-1029-DG.

3 - STRAPS "AA". "AC". "AD" NORMALLY PROVIDED TO OBTAIN REQUIRED PERCENT BREAK. ADD OR CUT STRAPS "AA". "AB". "AC". OR "AD" AS REQUIRED. EACH 2000 OHMS AFFECTS THE PERCENT BREAK APPROXIMATELY 1%-2%.

4 - FACTORY CONNECTS STRAPS "U1". "U2". "U3". "U4" and "H" (NOTE 78).

5 - FACTORY OMITS WIRING "G".

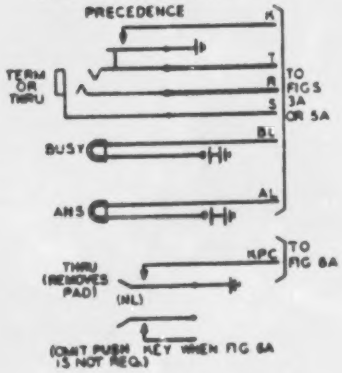
6 - FACTORY CONNECTS STRAP "P" UNLESS FIGURE 6A IS SPECIFIED.

7 - FACTORY OMITS STRAP "X" IF FIGURE 6A IS SPECIFIED.

8 - IN ORDERING FIGURE 25A ONLY.
THE FOLLOWING DIODES ARE LOCATED ON TERMINAL BOARD ASSEMBLY D-35532-A: CR1 TO CR24 IN POSITIONS 1 TO 24: CR41 to CR45 IN POSITIONS 25 TO 29: AND CR51 IS IN POSITION 30

FIG. JK1

SWITCHBOARD EQPT.
FOR UNIVERSAL & TOLL BOARDS
(FOR REF ONLY)
ORDER AS H-33822 FIG 33A

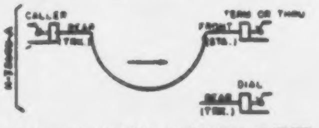


MAINTENANCE AND OPERATION NOTES:

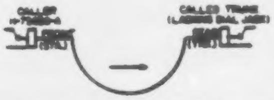
90 - RELAYS PT AND SR SHALL BE ADJUSTED IN THE FIELD TO HAVE THE FOLLOWING RELEASE INTERVALS. RELAY PT-280 MILLISECONDS MINIMUM RELEASE TIME. RELAY SR-240 MILLISECONDS ± 20 MS RELEASE TIME.

91 - WITH "SIMPLIFIED" CORD CIRCUIT. USUALLY ATTENDANT CAN DIAL OR TOUCH-CALL THRU "TRUNK" (REAR) PLUG (ONLY). AND IF "TRUNK" (REAR) PLUG IS USED IN FIGURE JK2 "TERMINATING OR THRU" JACK. ATTENDANT NEED NOT USE "DIAL" JACK.

WHEN SIMPLIFIED CORD CIRCUIT'S "TRUNK" (REAR) PLUG HAS BEEN USED TO ANSWER CALLER. SO "STATION" (FRONT) PLUG MUST BE USED IN FIGURE JK2 "TERMINATING OR THRU" JACK. ATTENDANT DIALS OR TOUCH-CALLS THRU ANOTHER CORD CIRCUIT'S "TRUNK" (REAR) PLUG IN FIGURE JK2 "DIAL" JACK:



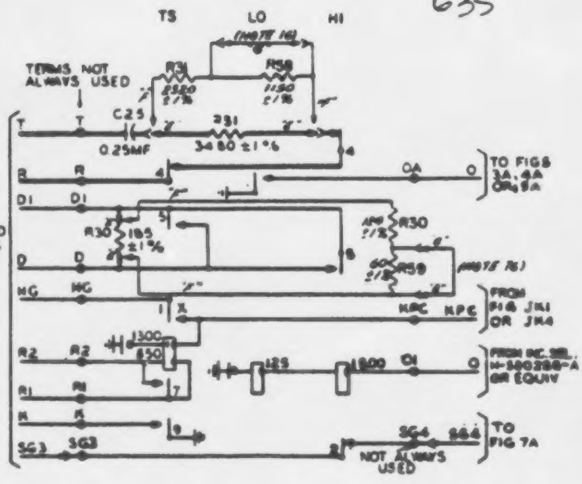
IF ATTENDANT HAS ANSWERED H-75650-A WITH SIMPLIFIED CORD CIRCUIT'S "TRUNK" (REAR) CORD. AND CALL IS TO BE EXTENDED TO ANOTHER TRUNK. LACKING DIAL JACK. ATTENDANT MUST "CHANGE CORDS" BECAUSE DIAL GOES ONLY ON "TRUNK" (REAR) CORD.



92 - DO NOT CONNECT TEST LAMP OR TEST RECEIVER TO TERMINAL 7 OF TIMERS T1 AND T2. AS THE LOW RESISTANCE OF TEST LAMP OR TEST RECEIVER WILL INTERNALLY DAMAGE TIMER.

FIG. 6A

PAD CONTROL CIRCUIT
(TABLE A)



ENGINEERING NOTES:

51 - ENGINEER SHALL SPECIFY FIGURES PER TABLES A AND B. SEE FIGURE AA AND AB FOR TYPICAL CIRCUIT LAYOUT.

52 - FIGURE 1A NORMALLY WIRED WITH "C" STRAP FOR USE OF THIS CIRCUIT WITH LENKURT CARRIER TYPE 45 OR EQUIVALENT. OR CX. DX SIGNALING FACILITIES. ENGINEER SHALL INSTRUCT THE INSTALLER TO CUT "C" STRAP AND ADD "D" STRAP WHEN THIS CIRCUIT IS USED WITH LENKURT CARRIER TYPE 33 OR EQUIVALENT.

53 - FIGURE 1A NORMALLY WIRED WITH "Y" STRAPS. ENGINEER SHALL INSTRUCT THE INSTALLER TO CUT "Y" STRAP WHEN USED WITH FIGURES 4A OR 5A.

54 - FIGURE 1A NORMALLY WIRED WITH "X" STRAP. ENGINEER SHALL INSTRUCT THE INSTALLER TO CUT "X" STRAP WHEN USED WITH FIGURES 3A. 4A. 5A. OR 7A. (SEE NOTE 7)

55 - FIGURE 1A NORMALLY WIRED WITH "W" STRAPS. ENGINEER SHALL INSTRUCT THE INSTALLER TO CUT "W" STRAP WHEN USED WITH FIGURE 7A.

56 - WHEN INCOMING SELECTOR IS NOT PROVIDED. ENGINEER SHALL INSTRUCT INSTALLER TO CONNECT "NS" WIRING IN FIGURES 1A AND 3A. 4A OR 5A.

57 - FIGURE 4A NORMALLY WIRED WITH "S" AND "T" STRAPS. ENGINEER SHALL INSTRUCT THE INSTALLER TO CUT "T" STRAP AND GROUND KD1 WHEN CORD CIRCUIT H-73422 OR EQUIVALENT IS USED. IF STATION THRU-CORD DIALING IS REQUIRED. CUT "S" STRAP.

58 - FIGURE 2A NORMALLY WIRED WITH "PR" STRAPS AS SHOWN ON ALL NID AND PNID CALLS. FIRST DIGIT ALWAYS STEPS SWITCH RS1 TO MARK CALL'S PRIORITY (IF ANY). ON INCOMING PRIORITY CALLS TO A CALLED STATION THAT IS BUSY OR DOES NOT ANSWER (WITHIN 12 TO 15 SECONDS). THE CALL IS DIVERTED TO PRECEDENCE ATTENDANT.

59 - FIGURE 1A NORMALLY WIRED WITH "BS" STRAP FOR BATTERY SEARCHING SELECTOR ACCESS. ENGINEER SHALL INSTRUCT THE INSTALLER TO CUT "BS" STRAP WHEN THIS CIRCUIT IS ACCESSED BY ABSENCE OF GROUND SEARCHING SELECTORS.

60 - FIGURES 3A. 4A. AND 5A NORMALLY WIRED WITH AL1 LEAD FROM FIGURES JK1 & JK2 TERMINATED ON TERMINAL L1. ENGINEER SHALL INSTRUCT THE INSTALLER TO WIRE AL1 LEAD FROM FIGURE 7A ON TERMINAL L1. WHEN ANSWER OF RECALL SIGNAL IS TO APPEAR AT RECALL POSITION.

61 - FIGURE 1A NORMALLY WIRED WITH "YY" STRAP. ENGINEER SHALL INSTRUCT INSTALLER TO CUT "YY" STRAP WHEN USED WITH FIGURE 5A.

62 - ORDER PRINT(S) H-850615-A FOR CUSTOMER'S FILES.

Foldout 3c.Two-way PABX interface trunk circuit.

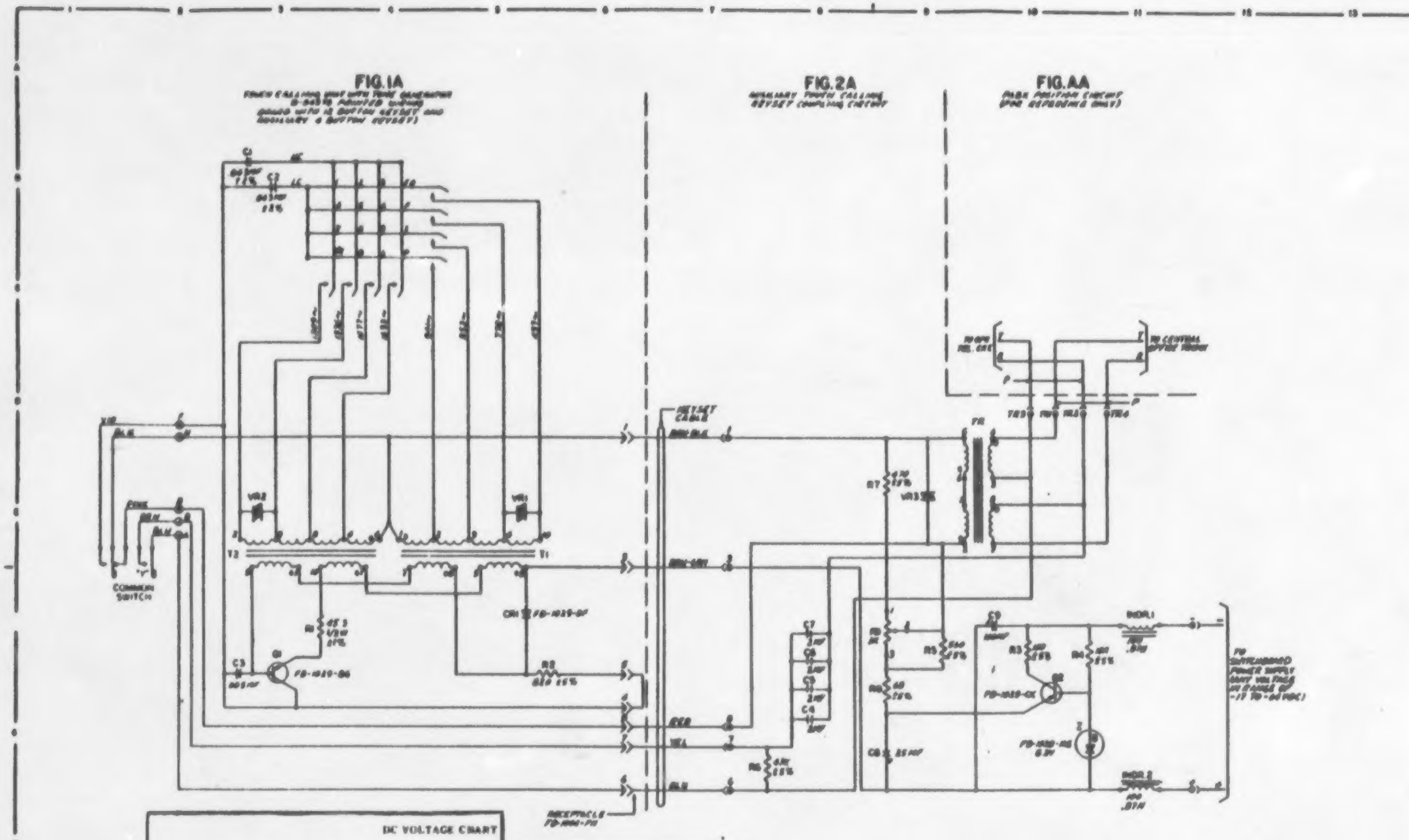


FIG.1A
TOUCH CALLING UNIT WITH TONE GENERATING PRINTED WIRING BOARD WITH 12 BUTTON KEYSET AND AUXILIARY 4 BUTTON (KEYSET)
FIG.2A
AUXILIARY TOUCH CALLING KEYSET (COUPLING CIRCUIT)
FIG.AA
PARK POSITION CIRCUIT (FOR REFERENCE ONLY)
COMMON SWITCH
KEYSET CABLE
RECEPTACLE
TO CENTRAL OFFICE TRUNK
TO SWITCHBOARD POWER SUPPLY
T1
T2
Q1
Q2
CR1
VR1
VR2
INDR.1
INDR.2

SYMBOLS

- INDICATES START OF WINDING.
- SOLDER TERMINAL ON PRINTED CARD
- TERMINAL STRIP TERMINAL ON COUPLING UNIT

MANUFACTURING NOTES

1-"T" CONTACTS ON COMMON SWITCH MAKE FIRST.

2-GROUND MAY BE SWITCHED (IN THE POSITION CIRCUIT) TO REMOVE POWER FROM TOUCH CALLING UNIT WHEN NOT IN USE.

3-LEVEL CONTROL R?: OUTPUT LEVEL IS MAXIMUM (ABOUT -3 DBM PER FREQUENCY [illegible]) WHEN THE WIPER OF R? IS AT THE R6 END OF ITS RANGE. OUTPUT LEVEL IS MINIMUM (ABOUT -9.5 DBM PER FREQUENCY [illegible])

4-AUTOVON: WHEN INSTALLED IN PBX SWITCHBOARD WHERE TRANSMISSION LEVEL IS -2DBMO (-2DBM), LEVEL ADJUSTMENT R? SHALL BE SET SO THAT OUTPUT LEVEL TO CENTRAL OFFICE TRUNK IS NO HIGHER THAN -4DBM FOR THE HIGH FREQUENCY (1209~). THIS TONE IS GENERATED BY SIMULTANEOUSLY PUSHING TWO BUTTONS IN THE LEFT HAND VERTICAL COLUMN (1,4,7,*). IT IS RECOMMENDED THAT THE NOMINAL LEVEL BE SET AT -6DBM (-8DBM @ PER FREQUENCY, PARTICULARLY ON LEASED FACILITIES WHERE POWER LIMITATIONS ARE IMPOSED. TO PRESERVE ADEQUATE LINE LOSS MARGINS, IT IS RECOMMENDED THAT THE NOMINAL LEVEL OF ANY SINGLE TONE NOT TO BE LESS THAN -10DBM (-12DBM @

OUTPUT LEVEL/FREQ	VOLTS RMS					
	AUTOVON TRUNK TERMINATION					COMMERCIAL
	400	600	1000	1500	900	900
[illegible]	390	405	632	770	590	—
-6DBM	317	380	501	614	475	475

5-COMMERCIAL: LEVEL SHOULD BE SET AT -6DBM MEASURED AT THE CENTRAL OFFICE 900 OHM TERMINATION. ON LONG CENTRAL OFFICE TRUNKS THERE MAY BE INSUFFICIENT LEVEL TO MEET THE [illegible]

6-THE MAXIMUM LENGTH OF THE CABLE FROM THE KEYSET TO THE AUXILIARY COUPLING CIRCUIT SHOULD BE 70 FEET OF 24 GAUGE CABLE.

7-CURRENT DRAIN
GENERATING TONES: 13.5 MA @ 17V AND 20MA @ 84V.
IDLE: 1.5 MA @ 17V AND 6 MA @ 84V

8-MAXIMUM LENGTH OF CABLE FROM AUXILIARY COUPLING CIRCUIT TO PARK POSITION CIRCUIT TO BE 70 FEET.

DC VOLTAGE CHART

TEST POINT (-)	TEST POINT (+)	VOLTS DC
Q1 BASE	PIN 3	-0.73
Q1 EMITTER	PIN 3	-0.53
Q1 COLLECTOR	PIN 3	-4.73
Q2 BASE	JUNCTION OF DIODE 2 AND INDR 2	-8.30
Q2 EMITTER	JUNCTION OF DIODE 2 AND INDR 2	-8.10
Q2 COLLECTOR	JUNCTION OF DIODE 2 AND INDR 2	NOTE 2

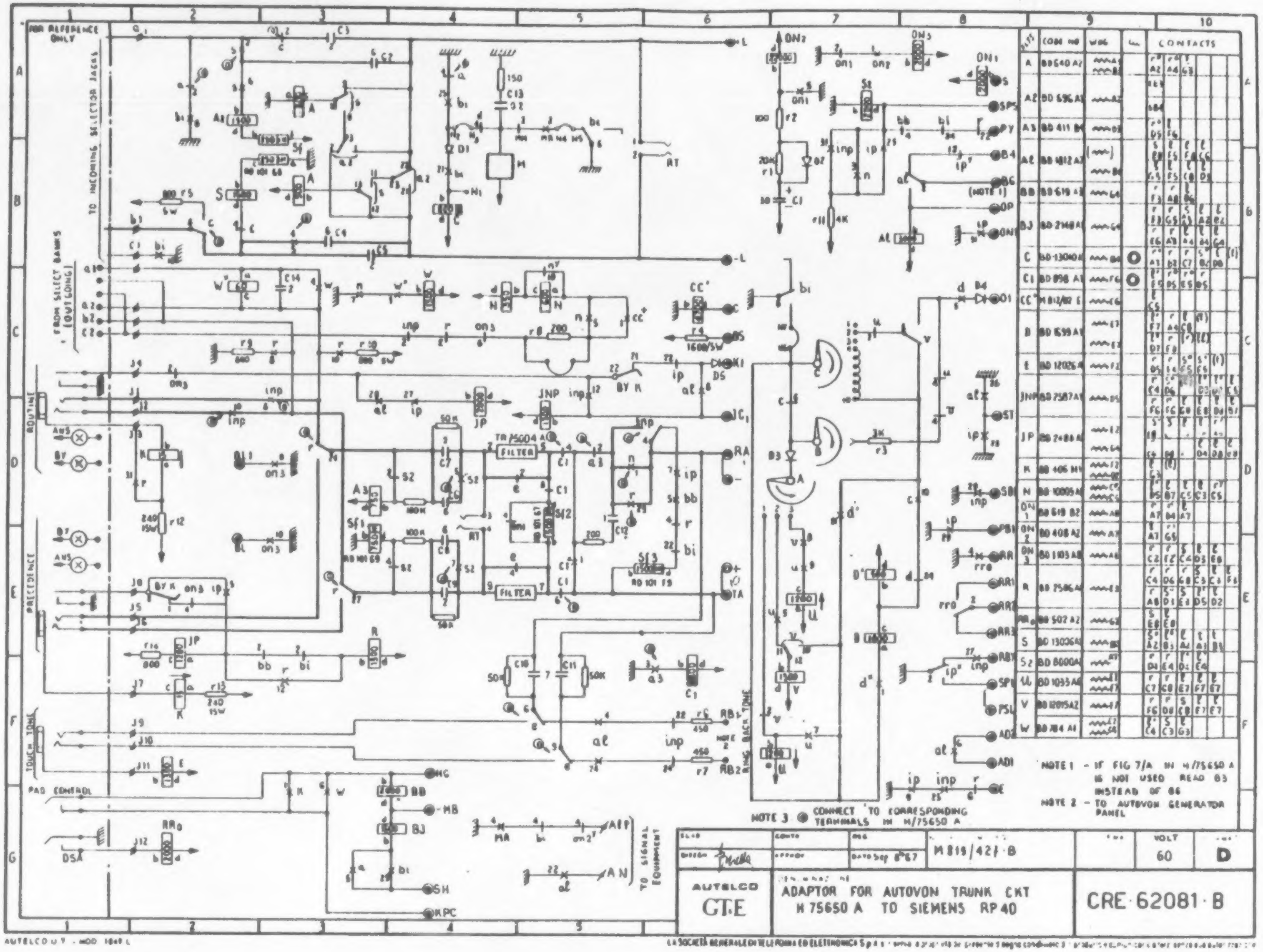
NOTES

1 VOLTAGES MEASURED WITH ANY TWO KEYSET PUSHBUTTONS IN THE SAME DIAGONAL ROW DEPRESSED. USE MULTIMETER AN/PSM-4

2 Q2 COLLECTOR VOLTAGE VARIES WITH PARTICULAR SWITCHBOARD SUPPLY VOLTAGE (BETWEEN -17 AND -84 VDC)

A1A71-6-08

Foldout 4. DTMF keyset, schematic diagram.


FOR REFERENCE ONLY
TO INCOMING SELECTOR JACKS
FROM SELECT BANKS (OUTGOING)
ROUTINE
PRECEDENCE
TOUCH TONE
PAD CONTROL
TO SIGNAL EQUIPMENT
RING BACK TONE
CONTACTS
NOTE 1 - IF FIG 7/A IN M/75650 A IS NOT USED READ B3 INSTEAD OF B6
NOTE 2 - TO AUTOVON GENERATOR PANEL
NOTE 3 ● CONNECT TO CORRESPONDING TERMINALS IN M/75650 A
DATA Sep 8 '67
M 819/421 · B
VOLT
60
D
AUTELCO
GT.E
ADAPTOR FOR AUTOVON TRUNK CKT
M 75650 A TO SIEMENS RP 40
CRE · 62081 · B
AUTELCO U.T. - MOD. 1049 L
LA SOCIETÀ GENERALE DI TELEFONIA ED ELETTRONICA S.p.A.

Foldout 5. Adaptor for AUTOVON trunk circuit.

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VOLTAGE AND RESISTANCE CHART, CONTROL UNIT

TEST POINT	RESISTANCE (OHMS)	VOLTS DC			
		N AND M LEADS AT GND	N AT GND M AT -48 VDC	N OPEN M AT GND	N OPEN M AT -48 VDC
Q1 EMITTER	0.9K	-0.85	-0.85	-0.85	-0.85
Q1 BASE	1 MEG	-1.0	-1.0	-1.0	-1.0
Q1 COLLECTOR	10.5K	-8.1	-8.1	-8.1	-8.1
Q2 EMITTER	2.3K	-8.0	-8.0	-8.0	-8.0
Q2 COLLECTOR	2.2K	-16.5	-16.5	-16.5	-16.5
Q3 EMITTER	1.6K	-17.2	-17.2	-17.2	-17.2
Q4 EMITTER	7.5K	-16.4	-16.4	-7.8	-7.8
Q4 BASE	3.8K	-0.84	-8.4	-8.4	-8.4
Q4 COLLECTOR	5.3K	-17.2	-17.2	-16.5	-16.5
Q5 COLLECTOR	2.1K	-0.7	-0.7	-12.3	-12.3
Q6 BASE	2.9K	-16.8	-17.0	-24.6	-24.6
Q6 COLLECTOR	7.2K	-17.0	-17.2	-17.2	-0.02
Q7 EMITTER	0.15K	-0.42	-0.425	-0.58	-0.58
Q7 BASE	6.3K	-0.66	-0.66	-0.01	-0.01
Q7 COLLECTOR	1.6K	-0.44	-0.44	-16.5	-16.5
Q8 BASE	4.0K	-0.06	-0.06	-0.75	-0.75
Q8 COLLECTOR	1.3K	-17.6	-17.8	-0.5	-0.5
Z1 PIN 2	4.0K	-16.6	-16.9	-14.0	-14.0
Z1 PIN 1	6.7K	-13.3	-13.5	-17.2	-17.2
Z1 PIN 10	5.4K	-15.2	-15.2	-16.9	-16.9
Z1 PIN 12	5.5K	-15.2	-15.2	-16.9	-16.9
Z1 PIN 9	(CW) 5.5K (CWW) 3.1K	-17.2	-17.2	-13.5	-13.5
Z1 PIN 7	(CW) 5.0K (CCW) 4.7K	-17.0	-17.0	-15.4	-15.4
Z1 PIN 8	3.2K	-17.0	-17.1	(CW) -16.0 (CCW) -13.5	(CW) -16.0 (CCW)-13.5
Z1 PIN 6	12K	-13.3	-13.5	-17.0	-17.0
Q9 BASE	6.6K	-16.3	-16.5	-17.0	-17.0
Q9 COLLECTOR	4.7K	-17.0	-17.2	-0.01	-0.01
Q10 BASE	19.7K	-1.1	-1.1	-0.01	-0.01
Q10 COLLECTOR	2.2K	-0.85	-0.85	-16.6	-16.6
Q10 EMITTER	0.23K	-0.83	-0.83	-2.5	-2.5
Q11 BASE	2.6K	-0.23	-0.23	-2.9	-2.9
Q11 COLLECTOR	1.3K	-46.0	-46.0	-2.75	-2.75
Z1 PIN 11	0.65K	-12.8	-12.8	-12.8	-12.8
Z1 PIN 4	1.6K	-17.2	-17.2	-17.2	-17.2
JUNCTION R48 AND C13	1.6K	-17.2	-17.2	-17.2	-17.2

Foldout 6a.

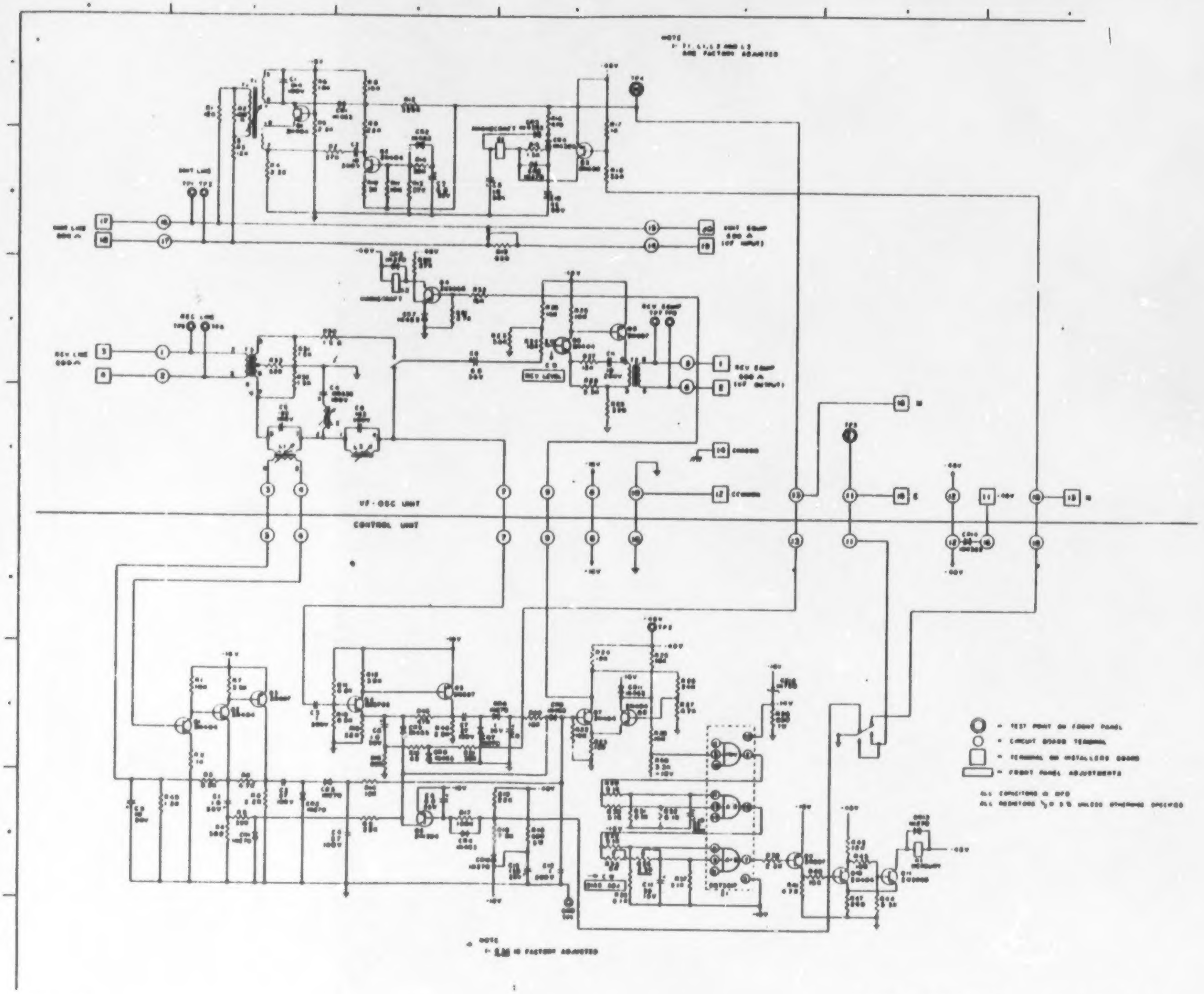
VOLTAGE AND RESISTANCE CHART, VF-OSC UNIT

TEST POINT	RESISTANCE (OHMS)	VOLTS DC			
		N AND M LEADS AT GND	N AT GND M AT -48 VDC	N OPEN M AT GND	N OPEN M AT -48 VDC
Q1 EMITTER	1.75K	-2.96	-3.0	-3.0	-3.0
Q1 BASE	2K	-3.2	-3.3	-3.2	-3.2
Q1 COLLECTOR	1.75K	-17.0	-17.2	-17.0	-17.2
Q2 EMITTER	35K	0.0	-43.0	0.0	-43.0
Q2 BASE	22K	0.0	-37.5	0.0	-37.5
Q2 COLLECTOR	27K	-15.5	-37.1	-15.5	-37.1
Q3 EMITTER	7.5K	-46.0	-46.0	-46.0	-46.0
Q3 BASE	8.5K	-45.5	-45.5	-46.0	-46.0
Q3 COLLECTOR	50K	-46.0	-46.0	0.0	-45.8
Q4 EMITTER	4K	-0.68	-0.66	-0.70	-0.70
Q4 BASE	2.7K	-0.08	-0.08	-1.1	-1.1
Q4 COLLECTOR	3.8K	-46.0	-46.0	-0.96	-0.96
Q5 EMITTER	(CW) 2.4K (CCW) 2.0K	-3.3	3.3	-3.3	-3.3
Q5 BASE	(CW) 12K (CWW) 3K	-3.4	-3.4	-3.4	-3.4
Q5 COLLECTOR	(CW) 2.5K (CCW) 2.0K	-16.7	-16.7	-16.7	-16.7
Q6 EMITTER	1.5K	-17.3	-17.3	-17.3	-17.3
Q6 BASE	(CW) 2.5K (CCW) 2.0K	-16.7	-16.7	-16.7	-16.7
Q6 COLLECTOR	0.2K	-3.3	-3.3	-3.3	-3.3
JUNCTION R8 AND R9	15K	-15.5	-17.9	-15.5	-17.9
PIN 8	1.75K	-17.3	-17.3	-17.3	-17.3

NOTES

1. ALL MEASUREMENTS TAKEN WITH RESPECT TO GROUND (TP1)
2. (CW) AND (CCW) INDICATE THAT MEASUREMENT IS TAKEN WITH RCV LEVEL CONTROL R24 ROTATED FULLY CLOCKWISE OR COUNTERCLOCKWISE, RESPECTIVELY.

Foldout 6 b.


VF-OSC UNIT
CONTROL UNIT
= TEST POINT ON FRONT PANEL
= CIRCUIT BOARD TERMINAL
= TERMINAL ON INSTALLERS BOARD
= FRONT PANEL ADJUSTMENTS
ALL CAPACITORS IN UFD
ALL RESISTORS ½ W 5% UNLESS OTHERWISE SPECIFIED

A1A71-1-15

Foldout 6c SF signaling set, schematic diagram.

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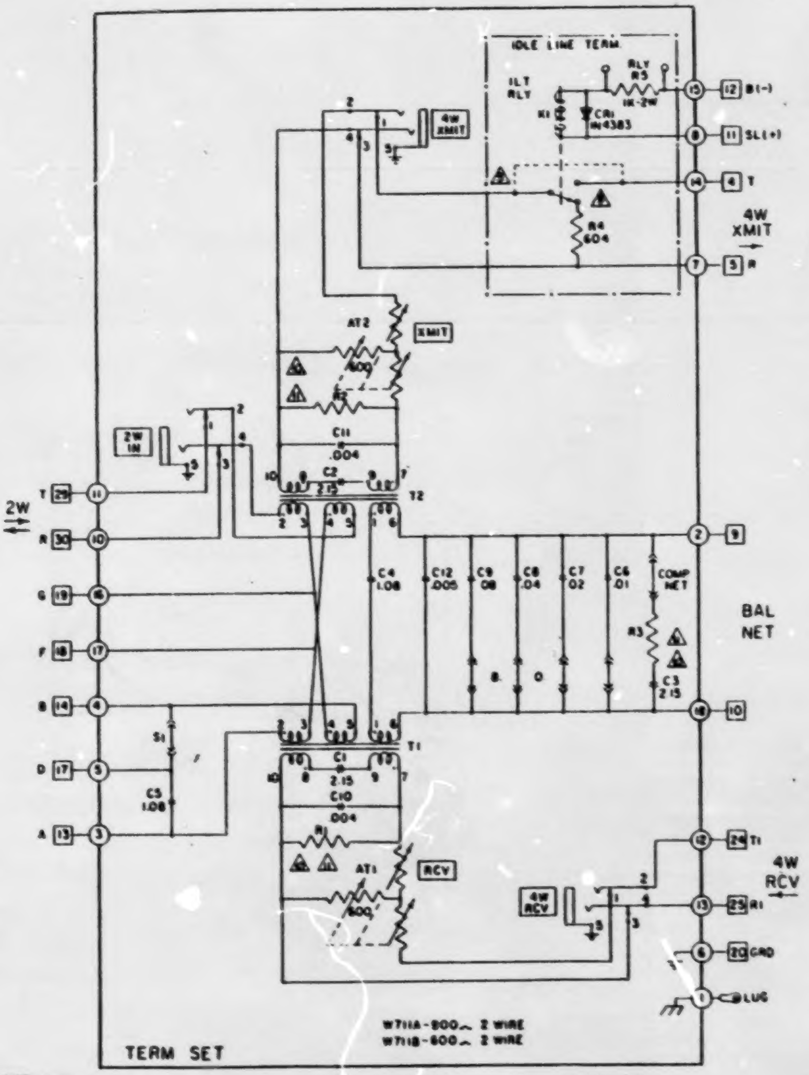
VOLTAGE AND RESISTANCE CHART

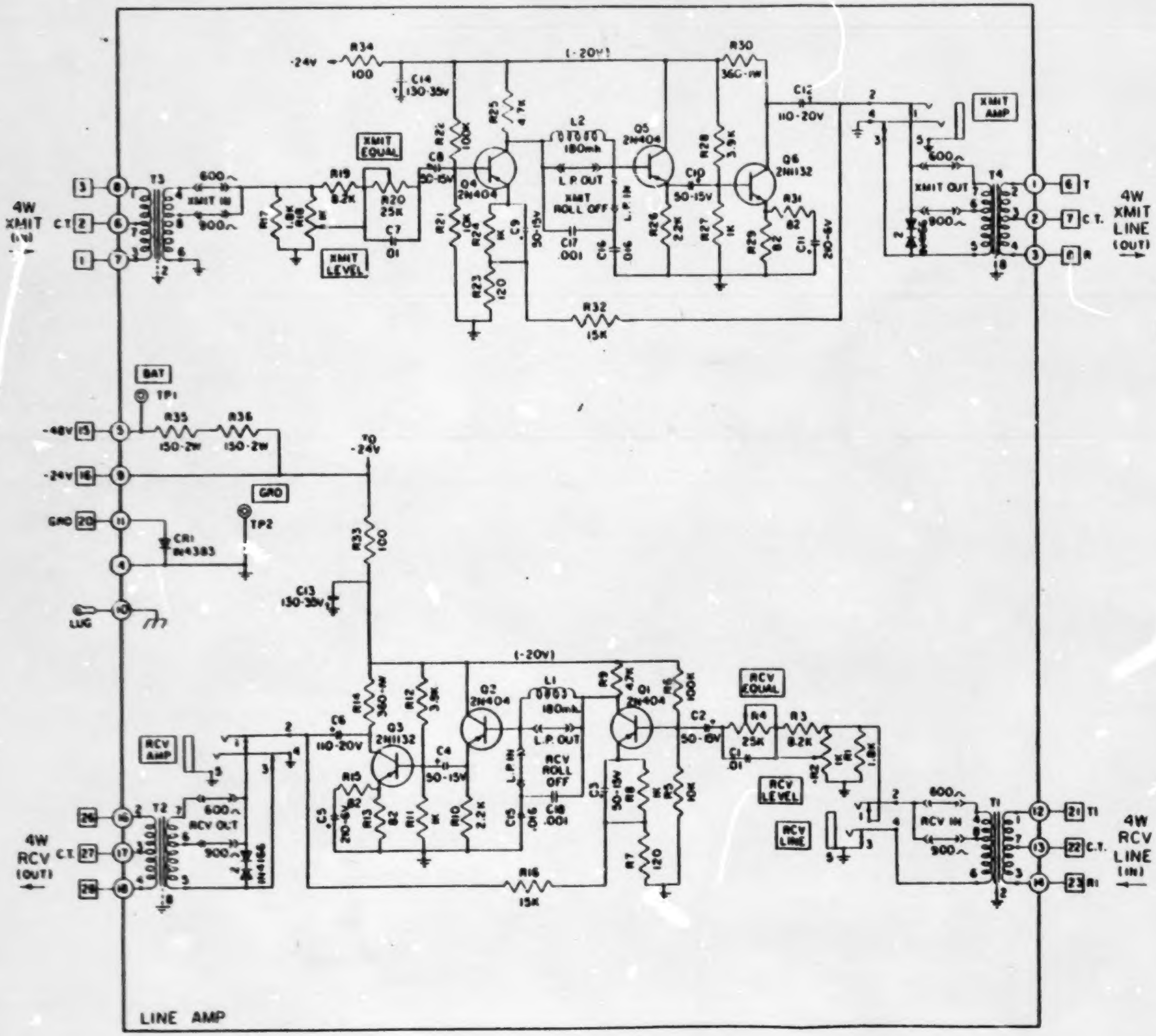
TEST POINT	VOLTS DC	RESISTANCE (OHMS)
Q1 BASE	-1.5	8600
Q1 EMITTER	-1.4	950
Q1 COLLECTOR	-11.5	1800
Q2 BASE	-11.5	1800
Q2 EMITTER	-11.3	1100
Q3 BASE	-3.3	800
Q3 EMITTER	-2.6	50
Q3 COLLECTOR	-7.0	1400
Q4 BASE	-1.5	8600
Q4 EMITTER	-1.4	950
Q4 COLLECTOR	-11.5	1800
Q5 BASE	-11.5	1800
Q5 EMITTER	-11.3	1100
Q6 BASE	-3.3	800
Q6 EMITTER	-2.6	50
Q6 COLLECTOR	-7.0	1400

NOTE: ALL MEASUREMENTS TAKEN WITH RESPECT TO GROUND (TP3)



A1A71-1-14

Foldout 7a.



NOTES:

A GENERAL

1 - [3] INDICATES INSTALLER CONNECTION ON REAR OF ENCLOSURE

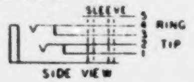
2 - (8) INDICATES PLUG IN DRAWER CONNECTION

3 - EITHER W711-TERM SET OR W711-LINE AMP MAYBE USED SEPARATELY

4 - ALL RESISTOR VALUES IN OHMS

5 - ALL CAPACITOR VALUES IN MFD

6 - ALL JACKS:



B TERM SET

7 - IDLE LINE TERMINATION (ILT) OPTION CONSISTS OF: K1, CR1, R4 & R5

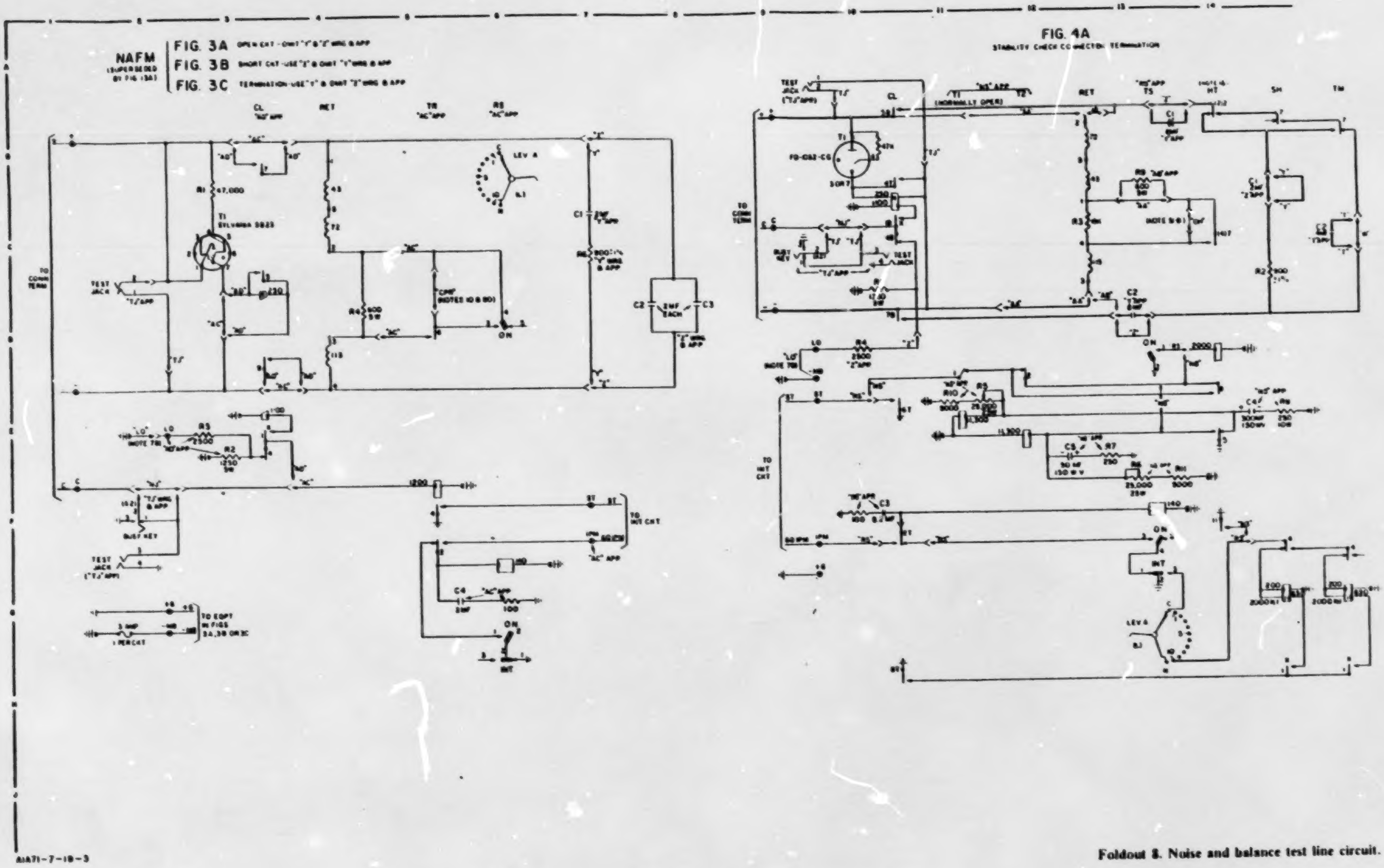
8 - K1 (K*) SHOWN NON OPERATED

⚠ WHEN IDLE LINE TERMINATION (ILT) IS NOT SUPPLIED, UNIT IS WIRED AS SHOWN BY DOTTED LINE

⚠ WITH 900∧ 2 WIRE (W711A) R1 & R2 ARE 5620∧. R3 IS 900∧.

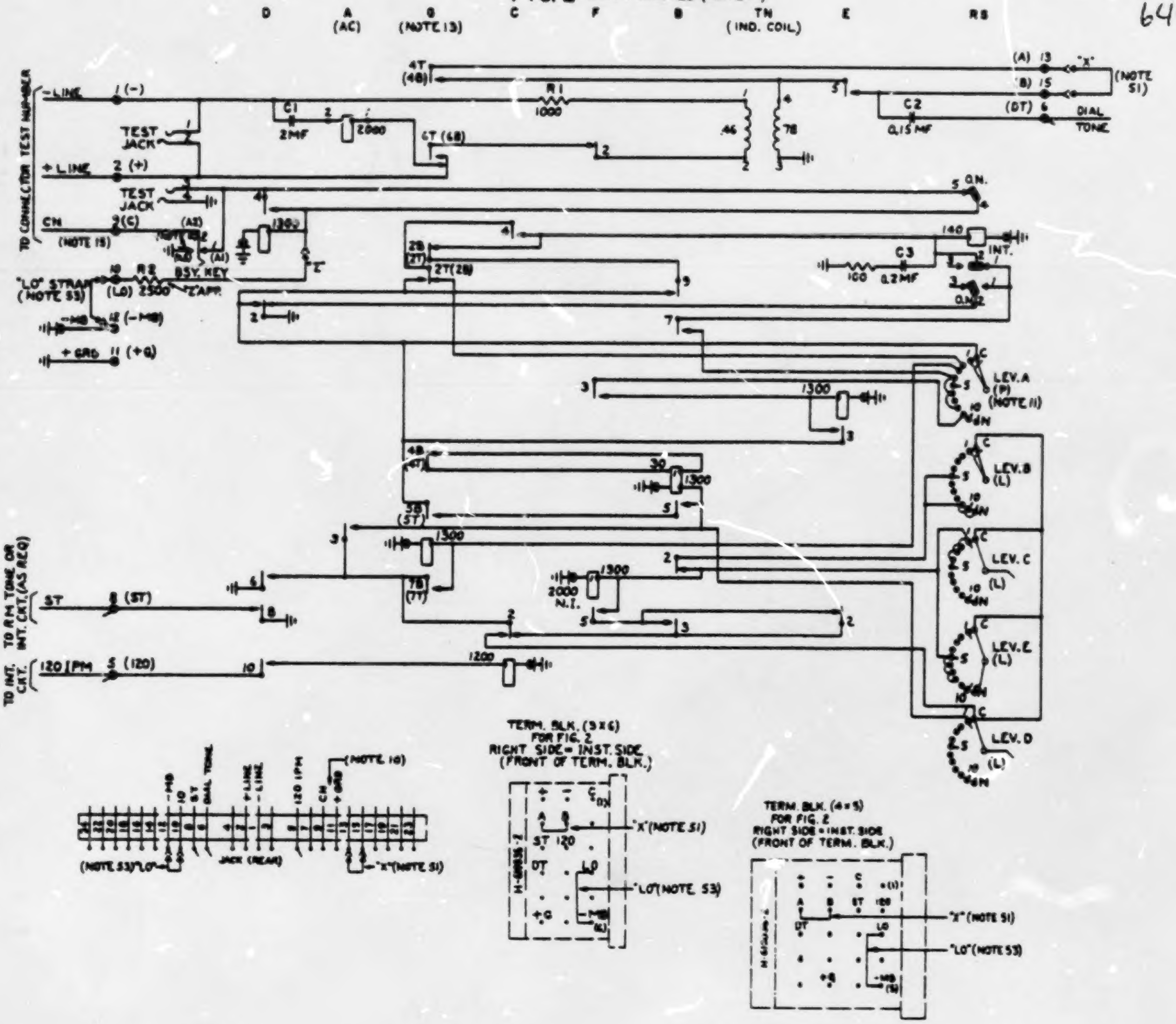
⚠ WITH 600∧ 2 WIRE (W711B) R1 & R2 ARE 3920∧. R3 IS 600∧

Foldout 7b. VF line amplifier and two-wire/four-wire terminating unit, schematic diagram.

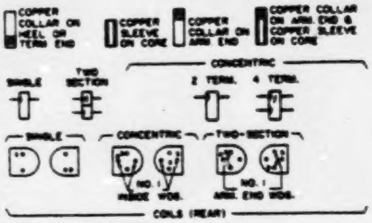

NAFM
(SUPERSEDED BY FIG. 3A)
FIG. 3A OPEN CKT - OMIT "Y" & "Z" WRG & APP
FIG. 3B SHORT CKT - USE "Z" & OMIT "Y" WRG & APP
FIG. 3C TERMINATION - USE "Y" & OMIT "Z" WRG & APP
CL
RET
TR
RS
LEV A
R1 47,000
T1
C1
C2
C3
R4
R3
R2
TO CONN TERM
TEST JACK
"TJ" APP
BUSY KEY
ON
INT
TO INT CKT
C4
TO EQPT IN FIGS 3A, 3B OR 3C
FIG. 4A
STABILITY CHECK CONNECTION TERMINATION
"NS" APP
(NORMALLY OPER)
T1
T2
TS
HT
SH
TM
R8
R5
R6
R7
R10
R11
LEV A
8IA71-7-19-3

Foldout 8. Noise and balance test line circuit.

FIG. 1 JACK MOUNTED (NOTE 14)
FIG. 2 UNIT MOUNTED (NOTE 14)



SYMBOLS



* INDICATES INSIDE TERMINAL
(SO) SLOW TO OPERATE
(SR) SLOW TO RELEASE
—●— JACK OR UNIT TERMINAL BLOCK TERMINAL.
—●— JACK OR UNIT TERMINAL BLOCK TERMINAL (COMMON)

MANUFACTURING NOTES:

10-SHELF JACKS 9 & 11 MAKE CONTACT WHEN SWITCH IS REMOVED.

11-ON ROTARY SWITCH "RS" LEVEL A IS NEAREST SWITCH MOUNTING BRACKET.

12-PRIOR TO ISSUE 3, "Z" WIRING & APPARATUS WERE NOT SHOWN. BEGINNING WITH ISSUE 3, "Z" WIRING & APPARATUS BECOMES PART OF CIRCUIT.

13-RELAY G SPRING NUMBERS SHOWN IN PARENTHESES( ) ARE FOR LEFT HAND MOUNTING.

14-TERMINAL DESIGNATIONS NOT IN PARENTHESES ARE FOR FIG.1.TERMINAL DESIGNATIONS IN PARENTHESES ARE FOR FIG. 2.

15-USE BUSY KEY SPRING NUMBERS IN PARENTHESES ( ) WHEN TURN TYPE KEY IS USED.

ENGINEERING NOTES:

51-OMIT STRAP "X" TO DELAY TONE UNTIL START OF 120 IPM FLASHES.

52-SUPERVISORY SIGNALS AFTER TWO RINGS HAVE BEEN RECEIVED ARE AS FOLLOWS:
1 - OFF HOOK -1 1/4 SEC.
2 - ON HOOK -1/2 SEC.
3 - OFF HOOK - 1 1/2 SEC.
4 - 120 IPM - 3 FLASHES
5 - ON HOOK - 2 SEC.
6 - OFF HOOK - 5 1/2 SEC.
7 - 2 SEC. ON HOOK 5 1/2 SEC. OFF HOOK SIGNALS ARE REPEATED UNTIL DISCONNECT.

53-INSTALLER SHALL PROVIDE "LO" STRAP WHEN FIG. 1 OR FIG.2 IS USED IN LEICH OFFICE.

STOCKLIST DH-610036-71 (FIG. 2)
STOCKLIST DH-610036-70 (FIG.2)
STOCKLIST DH-610036-40 (FIG.1)
MFG.DIS.→ RUNNING LIST RL-850961
JUMPER LIST JL-610036

Foldout 9. Reverse battery test line circuit.

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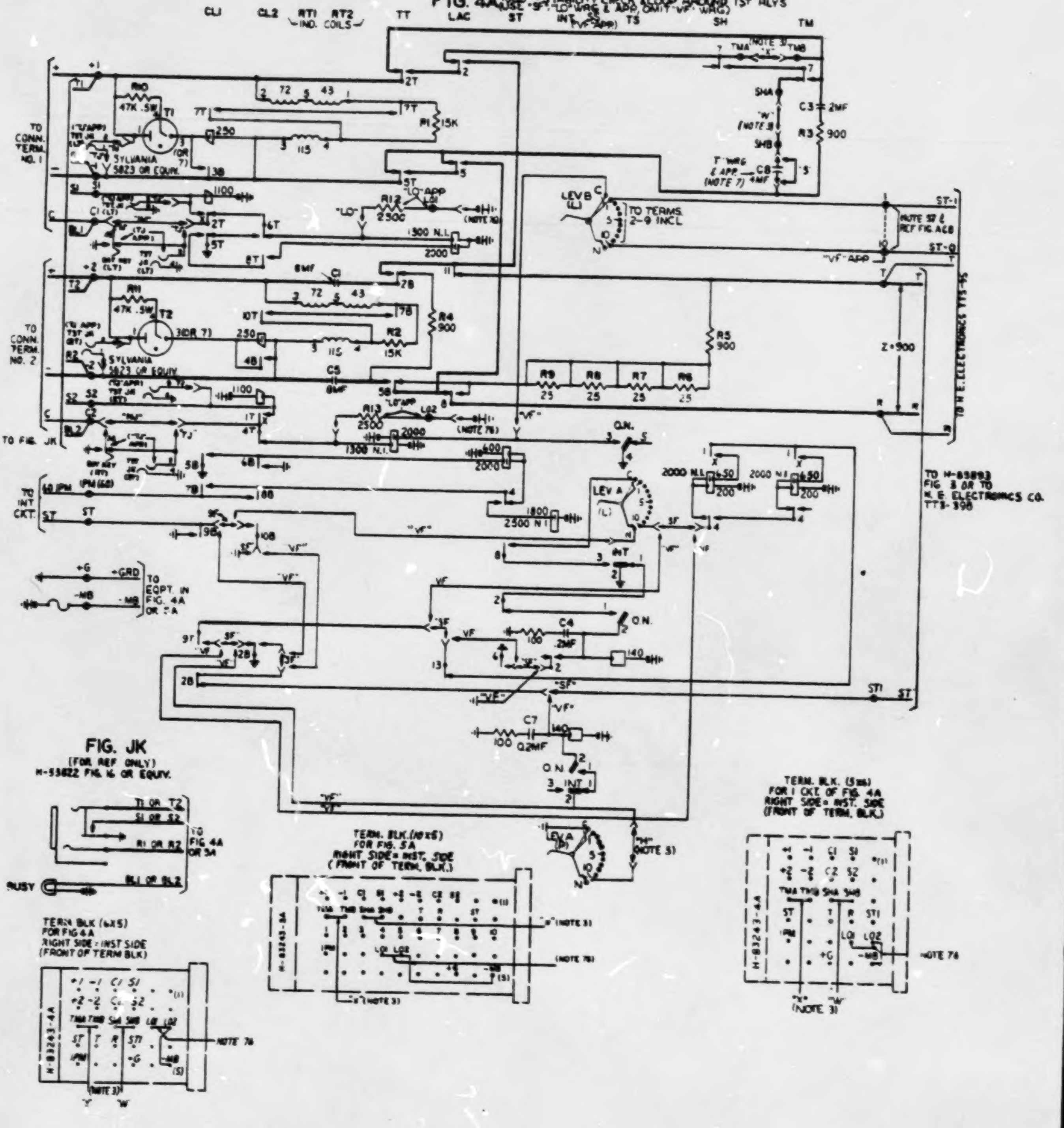
FIG 5A (1000~ OR VAR FREQ STABILITY CHECK & LOOP AROUND TST. RLYS. USE "VF", "LO" WRG & APP, OMIT "SF" WRG; NOTE 5B)

FIG. 4A (1000~ STABILITY CHECK & LOOP AROUND TST RLYS USE "SF", "LO" WRG & APP, OMIT "VF" WRG)



Foldout 10a.

FIG. A

(REF. FIG. FOR COMM TO 4 E.E. TTS-95I(3 FREQ)

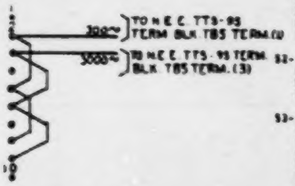
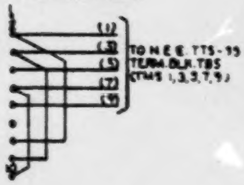
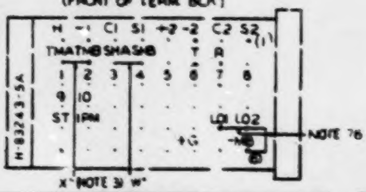

1
300~
TO N.E.E. TTS-95 TERM BLK TBS TERM.(1)
3000~
TO N.E.E. TTS-95 TERM. BLK. TBS TERM.(3)
10

FIG. B

(REF. FIG. FOR COMM TO NE E TTS-95X(6 FREQ)



TERM BLK (8 X 4)
FOR FIG 5A
RIGHT SIDE=INST. SIDE
(FRONT OF TERM. BLK)



ENGINEERING NOTES:

51-INSTALLER SHALL CUT STRAPS ON RESISTORS (R6-R9, R12-R15) TO COMPENSATE FOR WIRING LOSS FROM + AND - TEST LINE CIRCUIT TO THE OUTLET (CONNECTOR BANKS), E.I. MEASURED RESISTANCE FROM TERMINALS OF TEST LINES CIRCUIT TO SHORT CIRCUIT PLACED ACROSS OUTLET AT CONNECTOR BANKS.

52-INSTALLER SHALL PROVIDE "Z" STRAPS IN FIGURE 1A OR "Z1" STRAPS IN FIGURE 3A (WHEN EQUIPPED) WHEN OFF-HOOK SUPERVISION IS TO BE PROVIDED DURING TESTS.

53-IN FIGURE 3A, INSTALLER TO CONNECT OHA & OHC LEADS TO BANK CONTACTS OF LEVEL D & C RESPECTIVELY WHERE OFF-HOOK SUPERVISION IS TO BE PROVIDED; AND CONNECT 120 IPM TO BANK CONTACTS OF LEVEL B WHERE 5 SECOND TONE INTERVAL IS REQUIRED AND 60 IPM WHERE 10 SECOND TONE INTERVALS ARE REQUIRED.

54-IN FIGURE 2A, INSTALLER SHALL ADD "Y" STRAPS WHEN FIGURE 3A IS NOT EQUIPPED.

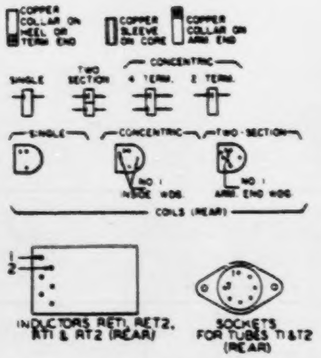
55-IN FIGURE 1A, INSTALLER TO ADD STRAP BETWEEN TERMINALS A & B WHEN FIGURES 2A & 3A ARE NOT EQUIPPED.

56-SPECIFY FIGURE 4A WHERE 1000 CYCLE TEST TONE ONLY IS TO BE PROVIDED ON TEST TERMINAL 2. SPECIFY FIGURE 5A WHERE VARIABLE FREQUENCY TEST TONE IS TO BE PROVIDED ON TEST TERMINAL 2

57- WHEN FIGURE 5A IS USED WITH NORTHEAST ELECTRONICS TTS-9 SERIES OF SUPPLIES, SEQUENCE CONTROLS THEREIN (IF EQUIPPED) ARE NOT USED, AND SEQUENCE CONTROLS ARE PROVIDED VIA TERMINALS (1-10) OF FIGURE 5A (SEE REFERENCE FIGURES). TTS 9 SERIES SUPPLIES ARE NORMALLY ARRANGED SO THAT 1000 CYCLE IS PROVIDED WITH NO START GROUNDS ON TB-S TERMINALS. WHEN START GROUND IS CLOSED TO ANY ONE OF THE TBS START TERMINALS, THE 1KC IS CHANGED TO OTHER FREQUENCY AS REQUIRED.

58-UNIT MANUFACTURED WITH VR3 & VR4 ADJUSTED TO PROVIDE 1200 OHM RESISTANCE BATTERY ON C LEAD. ENGINEER SHALL INSTRUCT INSTALLER TO ADJUST VR3 & VR4 TO PROVIDE RESISTANCE BATTERY ON C LEAD (INCLUDING R5 OR R6) EQUIVALENT TO RESISTANCE OF ASSOCIATED MANUFACTURER'S LINE CIRCUIT CUT-OFF RELAY.

SYMBOLS



• INDICATES INSIDE TERMINAL (START OF WINDING)
(SO) SLOW TO OPERATE
(SR) SLOW TO RELEASE
◆ TERMINAL ON UNIT TERMINAL BLOCK

MANUFACTURING NOTES:

1-CONTACTS "X" OPERATE FIRST.

2-ON ROTARY SWITCH, LEVEL "A" IS NEAREST MOUNTING FRAME.

3-FIGURE 1A WAS MANUFACTURED WITH "W" STRAP EQUIPPED AND CIRCUIT PROVIDES OPEN AND SHORT TERMINATION TESTS PRIOR TO TERMINATION TEST. INSTALLER SHALL REMOVE "W" STRAP AND CONNECT "X" STRAP WHEN TERMINATION (600 OHM, 2 MF) TEST ONLY IS REQUIRED.

4-PRIOR TO ISSUE 4,"M" WIRING WAS PART OF FIGURE 4A, FIGURE 5A ("VF" WIRING & APPTS LITTLE LATE 4(2) NOT SHOWN. CAPACITORS C1 & C3 WERE 5MF. CAPACITORS C2 & C4 REMOVED ON ISSUE 4, LO WIRING & APPARATUS BECOMES PART OF CIRCUIT FOR FIGURES 4A & 5A.

5-CIRCUIT MANUFACTURED WITH TERMINAL 10 OF LEVEL A SWITCH "SS" CONNECTED FOR HOMING AFTER 2 CYCLES OF 3 FREQUENCIES. WHEN 6 FREQUENCIES ARE PROVIDED, INSTALLER SHALL CUT STRAP "H".

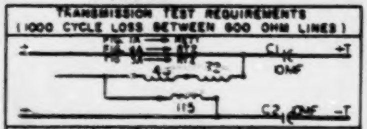
6-PRIOR TO ISSUE 5, FIGURES 6A & 7A WERE NOT SHOWN. BEGINNING WITH ISSUE 5, USE FIGURE 6A FOR 1 KC AND LOOP AROUND TEST. USE FIGURES 6A & 7A FOR VARIABLE FREQUENCY AND LOOP AROUND TEST

7-PRIOR TO ISSUE 8,"S" WIRING WAS PART OF FIGURE 4A & 5A AND "T" WIRING & APPARATUS WAS NOT SHOWN. "T" WIRING & APPARATUS SUPERSEDES "S" WIRING.

8-SHOP SHALL ADJUST VARIABLE RESISTOR VR1 TO OBTAIN 1/2 SECOND RELEASE TIME ON RELAY T1 AND ADJUST VR2 TO OBTAIN 1 SECOND RELEASE TIME ON RELAY T2.

9-PRIOR TO ISSUE 9, "HJ" WIRING WAS PART OF FIGURES 4A, 5A, 6A, & 8A AND "TJ" WIRING AND APPARATUS WAS NOT SHOWN. "TJ" WIRING & APPARATUS SUPERSEDES "HJ" WIRING.

TRANSMISSION TEST REQUIREMENTS
(1000 CYCLE LOSS BETWEEN 600 OHM LINES)



MAX ALLOWABLE CKT LOSS (DB)	0.1		
SUFFIX			
* INDICATES APP FOR WHICH INDIV. LOSSES ARE NOT REQ.			
ALLOWABLE INDIVIDUAL APPARATUS LOSSES (DB)			
APPARATUS	DESIG	MAX. LOSS	MIN. LOSS
IND COIL 15/115	RET1 OR RT2	0.1	
CAP 10MF	C1 & C2	0.01	

INSTALLING NOTES:

76-INSTALLER SHALL CONNECT BATTERY TO TERMINALS LO1 & LO2 WHEN CKT. IS TO BE PROVIDED IN LEICH OFFICES

77-WHEN ACCESSING FIGURES 4A, 5A, 6A OR 8A VIA TEST JACKS, SPRINGS 5 & 6 SHALL BE MOMENTARILY SHORTED TO OPERATE "C" LEAD RELAYS.

CURRENT DRAIN DATA:
FIGS. 1A, 2A & 3A HOLDING CURRENT
FIG. 4A HOLDING CURRENT

Foldout 10b End office loop around test circuit.

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STOP -

1. MATCH ANSWER SHEET TO THIS EXERCISE NUMBER.

2. USE NUMBER 2 PENCIL ONLY.

36251 05 22

EXTENSION COURSE INSTITUTE
VOLUME REVIEW EXERCISE

AUTOVON INTERFACE EQUIPMENT AND BASE WIRE SYSTEM

Carefully read the following:

DO'S:

1. Check the "course," "volume," and "form" numbers from the answer sheet address tab against the "VRE answer sheet identification number" in the righthand column of the shipping list. If numbers do not match, take action to return the answer sheet and the shipping list to ECI immediately with a note of explanation.
2. Note that item numbers on answer sheet are sequential in each column.
3. Use a medium sharp #2 black lead pencil for marking answer sheet.
4. Write the correct answer in the margin at the left of the item. (When you review for the course examination, you can cover your answers with a strip of paper and then check your review answers against your original choices.) After you are sure of your answers, transfer them to the answer sheet. If you *have* to change an answer on the answer sheet, be sure that the erasure is complete. Use a clean eraser. But try to avoid any erasure on the answer sheet if a all possible.
5. Take action to return entire answer sheet to ECI.
6. Keep Volume Review Exercise booklet for review and reference.
7. If *mandatorily* enrolled student, process questions or comments through your unit trainer or OJT supervisor.
   If *voluntarily* enrolled student, send questions or comments to ECI on ECI Form 17.

DONT'S:

1. Don't use answer sheets other than one furnished specifically for each review exercise.
2. Don't mark on the answer sheet except to fill in marking blocks. Double marks or excessive markings which overflow marking blocks will register as errors.
3. Don't fold, spindle, staple, tape, or mutilate the answer sheet.
4. Don't use ink or any marking other than a #2 black lead pencil.

NOTE: NUMBERED LEARNING OBJECTIVE REFERENCES ARE USED ON THE VOLUME REVIEW EXERCISE. In parenthesis after each item number on the VRE is the *Learning Objective Number* where the answer to that item can be located. When answering the items on the VRE, refer to the *Learning Objectives* indicated by these *Numbers*. The VRE results will be sent to you on a postcard which will list the *actual* VRE *items you missed.* Go to the VRE booklet and locate the *Learning Objective Numbers* for the items missed. Go to the text and carefully review the areas covered by these references. Review the entire VRE again before you take the closed-book Course Examination.

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Multiple Choice

1. (800) What services are available to automatic voice network (AUTOVON) subscribers?

   a. Four-wire, data transmission, and off-hook.
   b. Data transmission, off-hook, and conferences.
   c. Off-hook, conferences, and four-wire.
   d. Conferences, four-wire, and data transmission.

2. (800) A dual-tone multifrequency (DTMF) oscillator provides

   a. a 2600-Hz tone to mark trunks idle.
   b. the precise tone for preemption.
   c. the tones for network inward dialing (NID).
   d. four low-frequency and four high-frequency tones.

3. (801) The purpose of the interface equipment and related circuits is to interconnect

   a. AUTOVON circuits with PABX circuits.
   b. AUTOVON equipment with the networks.
   c. CONUS circuits with overseas networks.
   d. AUTOVON ringing current to PBX telephones.

4. (802) When the handset of an AUTOVON 4-wire telephone is lifted (off-hook), the

   a. M-lead is 48 volts positive.
   b. E- and M-lead are both positive.
   c. E-lead has a negative potential.
   d. M-lead has a negative potential.

5. (802) With the handset of the four-wire telephone in the cradle, what potential marks the PABX basic trunk circuit idle to the single frequency (SF) signaling set?

   a. Battery on E-lead.
   b. Ground on E-lead.
   c. Ground on M-lead.
   d. Battery on M-lead.

6. (802) In the on-hook condition, the SF signaling unit

   a. places ground on the M-lead.
   b. places battery on the M-lead.
   c. sends 2600 Hz to the AUTOVON switch.
   d. sends 2600 Hz to the basic trunk circuit.

7. (803) Refer to foldout 3. Figure 2A is normally wired with the basic trunk circuit so that the CONUS AUTOVON can be used to complete

   a. SWBD precedence outgoing calls.
   b. PNID calls.
   c. NOD calls.
   d. NID calls.

8. (803) Refer to foldout 2. When the calling PABX subscriber is dialing on an AUTOVON NOD call,

   a. relay C follows the dial pulses.
   b. the answer lamp on JK2 flashes with the pulses.
   c. relays B, ON, and C remain operated during pulsing.
   d. relay E sends the numerical information to the signal circuits.

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9. (804) The seizure of the incoming selector on a network inward dialing (NID) call is completed by the operation of

a. relay IN.
b. relay E.
c. relay DE.
d. relay C.

10. (804) What prevents the first digit received from AUTOVON from stepping the incoming selector on an NID call?

a. E contacts 6 and 7.
b. ES contacts 2 and 3.
c. DE contacts 5 and 6.
d. IN contacts 4T and 5T.

11. (804) If rotary switch access is used for the basic trunk circuit, the circuit is marked busy by

a. a ground on C-lead.
b. a ground on HU-lead.
c. the absence of a ground on C-lead.
d. the absence of a ground on Hu-lead.

12. (804) Refer to foldout 2. During an NID call the wink-start signal on the M-lead is controlled by

a. A contacts 5 and 6.
b. WK contacts 3 and 4.
c. DE contacts 5 and 6.
d. SD contacts 12 and 13.

13. (804) Refer to foldout 3, figure 2A. The first digit on an NID call will pulse

a. relay A.
b. relay C.
c. incoming selector mechanism.
d. rotary switch RS1.

14. (804) Refer to foldout 3. The first relay to operate on an NID call is

a. relay A.
b. relay E.
c. relay IN.
d. relay JNP.

15. (804) Refer to foldout 3. The relay that pulses the incoming selector on an NID call is

a. relay IN.
b. relay ES.
c. relay DE.
d. relay E.

16. (804) When the called party answers an NID call, relay SP in the trunk circuit operates from

a. the operation of C.
b. the operation of IN.
c. the called party hanging up.
d. reverse battery from the connector.

17. (804) When the called station answers an NID call, which relay operation completes a circuit to the distant end equipment?

a. Relay E.
b. Relay SP.
c. Relay ESS.
d. Relay SPS.

18. (805) Using foldouts 2 and 3, what causes the incoming selector to step in response to the first incoming digit?

a. Contacts 6 and 7 of relay E are shorted.
b. Contacts 6 and 7 of relay E are dirty.
c. The 5-6 winding of the hybrid (trunk side) is open.
d. The 3-4 winding of the hybrid (trunk side) is shorted.

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19. (806) What relay lights the precedence busy lamp during a precedence outgoing call from the attendant's cabinet?

a. PR. c. SPS.
b. AS. d. PSL.

20. (806) What relay provides an alternate path to keep the precedence busy lamp lighted until the trunk is released at both ends from a PNOD call?

a. AR. c. PSL.
b. PR. d. PBY.

21. (806) During a precedence outgoing call from the switchboard, the operate path for the PT relay is through contacts

a. 4 and 5 of relay SR. c. 8T and 9T of relay PSL.
b. 2 and 3 of relay ES. d. 3T and 4T of relay PSL.

22. (807) Which relay operation connects precedence ring back tone to AUTOVON?

a. Relay OP. c. Relay AR.
b. Relay P2. d. Relay AL.

23. (807) What is the period of time that a precedence network inward dialed (PNID) call will be diverted if the call is unanswered?

a. 12-second start. c. 3-second start.
b. 2-second start. d. 1.2-second start.

24. (807) The transfer of a PNID call which is not answered will cause the precedence

a. busy lamp to light constantly. c. answer lamp to flash at 120 IPM.
b. answer lamp to flash at 60 IPM. d. busy lamp to flash at 120 IPM.

25. (807) What relay action changes the condition of the M-lead when the operator first disconnects from a diverted PNID call?

a. A releasing. c. AR operating.
b. C operating. d. OP1 releasing.

26. (808) Refer to foldout 4. When the operator depresses button 8 on the DTMF keyset and only the high-frequency tone is transmitted, the probable cause of trouble is that capacitor

a. C1 is shorted. c. C4 is shorted.
b. C2 is open. d. 57 is open.

27. (809) Refer to foldout 5. What type of pulsing is applied to the incoming selector?

a. Tone. c. Ground.
b. Loop. d. Battery.

28. (809) What happens to relays A, BJ, and D if the calling party hangs up first following an NID call?

a. Reverse battery from the connector releases SP in H-75650.
b. A2 operates and restores the circuit.
c. The A relay is all that releases.
d. None of the above.

29. (810) Refer to foldout 5. What means is used to seize circuit H-75650-A?

a. Tone.
b. Loop.
c. High resistance ground.
d. Battery.

30. (811) Using foldout 5, what would be the results if capacitor C1 in circuit CRE-62081-B were open?

a. No calls would be processed.
b. ON2 would release too slowly.
c. No adverse effect on the circuit.
d. Circuit could be seized before being released.

31. (812) In the receive section of the SF signal set, when relay K1 operates, a

a. ground is placed on the E-lead to the trunk.
b. ground is placed on the M-lead to the trunk.
c. battery is placed on the E-lead to the trunk.
d. battery is placed on the M-lead to the trunk.

32. (813) Resistor R36 of the VF line amplifier provides

a. -24 volts DC.
b. -48 volts DC.
c. 600-ohm idle line termination.
d. 900-ohm idle line termination.

33. (814) Refer to foldout 9. What is the probable cause of a trouble if the oscillator unit relay K1 in the SF unit fails to operate when the trunk is idle?

a. Diode CR3 is open.
b. Resistor R15 is open.
c. Resistor R15 is shorted.
d. Diode CR3 is shorted.

34. (815) The access number normally assigned to the noise and balance test line circuit is

a. 21.
b. 22.
c. 31.
d. 41.

35. (815) When using the reverse battery test line circuit, how long will the continuous on-hook supervisory signal alarm after dialing access to the reverse battery test line circuit?

a. Off-hook for 5 1/2 seconds and on-hook for 2 seconds.
b. Off-hook for 1 1/2 seconds and on-hook for 1/2 second.
c. Off-hook for 1 1/4 seconds and on-hook for 1/2 second.
d. 120 IPM flashes.

36. (815) When using the end office loop around test circuit, how long will the AUTOVON technician receive an open-circuit line termination during the stability test?

a. 1 second.
b. 5 seconds.
c. 10 seconds.
d. 15 seconds.

37. (815) When the end office around test circuit is being used, the AUTOVON technician must access connector terminal No. 1 prior to connector terminal No. 2 to

a. make a stability test.
b. complete a loop around test.
c. access the 1000-Hz tone supply.
d. establish the dB loss of the access line.

38. (815) When using the end office loop around test circuit, AUTOVON will receive short-circuit line termination during the stability test for

a. 1 second.
b. 5 seconds.
c. 10 seconds.
d. 15 seconds.

39. (815) What load is used to terminate connector terminal No. 2 when seized by a technician to perform the loop around test?

a. 500-ohm, 2-microfarad.
b. 600-ohm, 4-microfarad.
c. 900-ohm, 8-microfarad.
d. 900-ohm, 16-microfarad.

40. (815) What operates the off-normal springs of a rotary switch when the wipers are at normal?

a. Off-normal cam lobe.
b. Ratchet stop spring.
c. Off-normal armature.
d. Off-normal lever arm.

41. (815) The completely automatic sequence of operation for the rotary switches used in the special test circuits is controlled by

a. 60 IPM ground.
b. 120 IPM ground.
c. the rotary switch interrupter contacts.
d. all of the above.

42. (815) To complete a stability test, the AUTOVON technician must access connector terminal

a. No. 1 with the access line of the known dB loss.
b. No. 2 with the access line of the known dB loss.
c. No. 1 prior to connector terminal No. 2.
d. No. 2 prior to connector terminal No. 1.

43. (815) Using the three-arm wiper arrangement on the rotary switches in the special test circuits, the bank contacts are traversed by

a. one fourth revolution of the wiper assembly.
b. one third revolution of the wiper assembly.
c. one half revolution of the wiper assembly.
d. one complete revolution of the wiper assembly.

44. (815) The special test circuit that employs the one-arm wiper arrangement on the rotary switch is

a. noise and balance test line circuit.
b. reverse battery test line circuit.
c. end office loop around test circuit.
d. line termination test.

45. (816) Refer to foldout 6. In the noise and balance test line circuit, the conduction of vacuum tube T1 simulates

a. on-hook supervision.
b. ringing of the called party.
c. called party answering.
d. battery reversal.

46. (816) In the noise and balance test line circuit, the homing circuit for rotary switch (RS) is opened by

a. TR contacts 1 and 2.
b. INT contacts 2 and 3.
c. INT contacts 1 and 2.
d. ON contacts 1 and 2.

47. (817) In the reverse battery test line circuit, the operate path for rotary switch (RS) during ringing current from the connector is controlled by

a. relay C.
b. relay A.
c. relay B.
d. relay D.

48. (817) The reverse battery test line circuit is marked idle by

a. absence of ground on lead CN.
b. (-) battery through resistor R2.
c. (-) battery through relay D.
d. ground on lead CN.

49. (817) Refer to foldout diagram 7. In the reverse battery test line circuit, relay A is operated by

a. DC loop across tip and ring.
b. ringing current.
c. shorted test jacks 1 and 2.
d. negative battery on (+) line.

50. (817) Refer to foldout diagram 7. Dial tone is returned from the reverse battery test line circuit

a. upon seizure of the test circuit.
b. after relay G operates.
c. during each on-hook signal.
d. during each off-hook signal.

51. (818) The end office loop around test circuit is marked idle at connector terminal No. 1 by

a. resistance battery through relay LAC.
b. resistance battery through relay CL1.
c. absence of ground.
d. ground on the B lead.

52. (819) When establishing known dB loss using the end office loop around test circuit, the AUTOVON technician would measure the

a. resistance of R-4.
b. capacitance of C-1 and C-5.
c. 1000-Hz, 0-dB tone provided by the TTS-39B.
d. total resistance of R9, R8, R7, R6, and R5.

53. (820) Refer to foldout 10. When establishing known dB losses and using the end office loop around test circuit, relay TT

a. is permanently operated.
b. holds through contacts 4T/3T of CL2.
c. pulses from the C-lead.
d. is operated for 10 seconds and released for 1 second.

54. (821) The test set which should be used to measure frequency is the

a. control signal generator.
b. 26A test set.
c. electronic test lamp.
d. electronic counter.

55. (821) When maintaining interface equipment, decibel levels are checked

a. with a vacuum tube voltmeter.
b. with a control signal generator.
c. with an electronic counter.
d. only during NOD calls.

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56. (821) The vacuum tube voltmeter is used primarily to measure

a. resistance and voltage.
b. current and decibels.
c. voltage and decibels.
d. decibels and resistance.

57. (821) An audio frequency oscillator

a. produces tones.
b. measures tones.
c. measures frequencies.
d. produces square waves.

58. (821) To check the overall quality of a transmitted signal to and from the switching center, you would use

a. a transmission test set.
b. a signaling test set.
c. an electronic counter.
d. a vacuum tube voltmeter.

59. (821) The electronic counter is used primarily to

a. count dial pulses.
b. control counters.
c. measure frequencies.
d. measure electronic voltage.

60. (822) What type of routine do you perform when you wish to check the frequency of the single frequency (SF) signaling set?

a. Type 2.
b. Type 3.
c. Operational.
d. Alignment and adjustment.

61. (822) What test equipments are required to perform a type I PMI on the DTMF keyset?

a. Audio oscillator and VTVM.
b. Electronic counter and VTVM.
c. Audio oscillator and test lamp.
d. Electronic counter and audio oscillator.

62. (822) When performing a type I PMI on the DTMF keyset, the electronic counter is set up to measure the

a. frequency of each tone.
b. level of each tone.
c. period of each tone.
d. voltage of each tone.

63. (823) The dual tone multifrequency (DTMF) keyset is normally aligned

a. monthly.
b. at the factory.
c. with the power turned off.
d. every two years.

64. (823) In order to properly adjust the precise tone supply, you would use the VTVM and

a. DC power supply.
b. electronic counter.
c. DTMF keyset.
d. screwdriver.

65. (823) When adjusting the VF line amplifier, you will need assistance from personnel at

a. other shops.
b. the switchboard.
c. the distant end.
d. the receiver site.

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66. (823) Single frequency (SF) signalling units for your equipment are located in the

a. central office, if you are located in the states.
b. AUTOVON switch.
c. tech control facility, if you are located in the states.
d. central office, if you are located overseas.

67. (824) What type of cables are used to connect main feeder cables to distribution terminals?

a. Trunk cables.
b. Feeder cables.
c. Distribution cables.
d. Interlocal trunk cables.

68. (824) Which type of cable plant is least susceptible to damage?

a. Buried.
b. Aerial.
c. Underground.
d. Branch feeder.

69. (825) Which of the following symbols will never be found on an underground cable record?

a. Central office.
b. Cable number.
c. Manholes.
d. All of the above.

70. (824) When using a cable map, what indicates the difference between aerial and underground cable?

a. Rectangles for manholes on underground cable.
b. Underground cable is shown as a dotted line.
c. Circles for manholes on underground cable.
d. Aerial cable is shown as a dotted line.

71. (826) What unit is used to measure transmission loss?

a. Attenuation ration.
b. Milliwatt.
c. Decibel.
d. Volts.

72. (826) The characteristic impedance of a transmission line depends upon the

a. length of the line.
b. load placed on the line.
c. internal impedance of power supply.
d. distributed constants of the line.

73. (826) What is the primary reason for impedance matching?

a. Reduction of attenuation.
b. Provides for maximum power dissipation.
c. Provides the most efficient circuit operation.
d. Gives a maximum transfer of power.

74. (827) Impulse noise can best be eliminated from cable circuits by

a. use of line amplifiers.
b. use of pressurization.
c. careful maintenance of central office equipment.
d. shielding mechanical devices.

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75. (827) Crosstalk will most likely result from which one of the following conditions?

a. Inductive/capacitive coupling.
b. Differential voltage between two conductors.
c. Make and break contacts in switching and signaling equipment.
d. Moisture and mineral salts in damp cable.

76. (828) Which one of the following conditions is a characteristic of a frequency distorted transmitted wave?

a. High-frequency component is attenuated more than the low-frequency component.
b. Low-frequency component is attenuated more than the high-frequency component.
c. The low-frequency component phase shift is less than the high-frequency phase shift.
d. The phase shift is directly proportional for both frequency components.

77. (829) What test equipment is required to perform an insulation resistance test?

a. AN/PSM2A.
b. AN/PSM6A.
c. HP 236A.
d. HP 3555B.

78. (829) The primary purpose for making an impulse noise test is to measure the

a. electric impulses at the transmitting end.
b. disturbances with abrupt changes and of short duration.
c. amount of electrical noise present on the cable pair.
d. loss occurring because of feedover from another source.

79. (829) The purpose for making the idle channel noise test is to measure the

a. loss occurring because of feedover.
b. electric impulses at the transmitting end.
c. amount of electrical noise present on the cable pair.
d. disturbances having abrupt changes of short duration.

80. (829) What test equipment is required for the frequency response test?

a. Test oscillator and VTVM.
b. Noise test set and AN/PSM-6.
c. Transmission and noise test set.
d. Test oscillator and transmission and noise set.

81. (830) What information is normally extracted from a cable map to start a performance test record?

a. Length of cable.
b. Loaded or non-loaded.
c. Gauge of cable.
d. All of the above.

82. (830) Frequency response, idle channel noise, and impulse noise tests results are recorded on

a. AFTO Form 484.
b. AFTO Form 485.
c. AFTO Form 494.
d. AFTO Form 376.

83. (831) While setting up for the impulse noise test, the reference level of hits recorded will be set to read

a. 15 hits in 15 minutes.
b. 15 low hits in 15 minutes.
c. 30 high hits in 15 minutes.
d. 30 high hits in 30 minutes.

84. (831) What is placed at the distant frame or terminal for loaded cable during an idle channel noise test?

a. Short.
b. Open.
c. 600-ohm resistor.
d. 900-ohm resistor.

85. (831) What is the decibel reference level set at for the impulse noise test (voice)?

a. 72 dBrn.
b. 58 dBrn.
c. 50 dBrn.
d. 90 dBrn.

86. (831) When using the transmission and noise measuring test set to check idle channel noise, the range switch is adjusted until the fluctuations of the meter

a. appear.
b. level off.
c. disappear.
d. fall in mid-scale.

87. (831) When performing the frequency response test, the function switch of the 236A test set will be set to either 600 ohms or 900 ohms if the

a. transmission noise measuring set is set to 600 or 900 ohms.
b. expected attenuation is to exceed 10 dB.
c. cable is pressurized.
d. cable is loaded.

88. (831) When performing the station ground resistance test, which lead, if any, is connected to the grounding electrode?

a. Terminal 1.
b. Terminal X.
c. Terminal 3.
d. None of the above.

89. (831) When performing a station ground resistance test, the galvanometer of the vibroground test set indicates

a. dBrn values for transmission level measurements.
b. the imbalance between equipment ground and earth ground.
c. if there is a grounding system for manmade and electronic grounds.
d. when the measuring system is balanced with the grounding electrode resistance.

90. (832) Maximum acceptable count for impulse noise on data circuit is

a. 90 hits at 58 dBrnc in 30 minutes.
b. 15 hits at 59 dBrnc in 15 minutes.
c. 95 hits at 58 dBrnc in 30 minutes.
d. 25 hits at 72 dBrnc in 15 minutes.

91. (832) When analyzing frequency response test results and the loaded pair is more than 10 percent off the standard loss at 1000 Hz, the pair may still be acceptable if the measured loss is within 20 percent of the

a. total facility loss.
b. effective facility loss.
c. measured facility loss.
d. total frequency loss.